

# ANNALS of SURGERY

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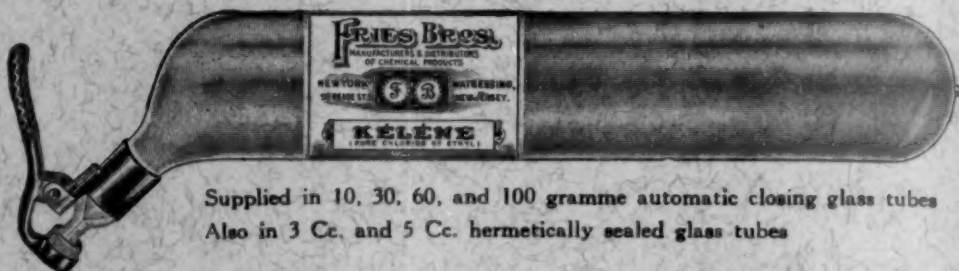
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## TRANSACTIONS AMERICAN SURGICAL ASSOCIATION

MEETING HELD JUNE 29, 30, JULY 1, 1931; *Continued*

### IDIOPATHIC DILATATION OF THE ŒSOPHAGUS

By FRANCIS A. C. SCRIMGER, M.D.

OF MONTREAL, CANADA

It is the intention to discuss, ultimately from the surgical aspect, a disease of the œsophagus which is neither new, since it was first described in 1821, nor really rare since several hundred cases are on record.

When there is in a considerable body of writing, as is shown in the appended bibliography which is continued from Newman's review of the subject in 1900, no agreement even as to the title, a wide divergence of opinion as to the ætiology, and no unanimity as to the treatment, further discussion is not only inevitable, but is even justified.

The term "idiopathic dilatation" has been chosen out of many, such as cardiopasm (Mikulicz), phrenospasm (Chevalier Jackson), achalasia cardiae (Hertez), megæsoophagus (Bard), dilatatio ingluvi formi œsophagi (Huss), dilatatio fusiformis (Luschka), and others; because it is one of those most commonly used and does not commit one to a belief in an ætiology, which to say the least is not proven.

It may be permissible for those who are interested briefly to review the history of the growing knowledge of the disease; and to indicate the various theories of its occurrence, leaving to a later period a more critical examination of those believed to be more important.

The first report of a case seems to be that of Purton, in the London Medical and Physiological Journal, volume xxxvi, 1821.

I can do no better than quote here his description of the clinical picture which I have not found improved. An extraordinary case of distention of the œsophagus, forming a sac extending from two inches below the pharynx to the cardiac orifice of the stomach, by T. Purton, F.L.S., F.R.C.S. "The present case, of more than twenty years standing, I believe to differ from any yet recorded. J. Broome, aged forty-three, received a severe blow over the breast bone when a youth, which deprived him for some minutes of sense of motion. Ever since, he has labored under more or less difficulty in swallowing. There have been many severe attacks continuing sometimes for three weeks or more and during the whole of this time scarcely any food entered the stomach. Occasionally, however, he was able for months together to propel by violent exertions the contents of the sac into the stomach.

"If the food was not propelled with a certain degree of force, he would reject it; so that latterly he never attempted to use any violent efforts, but would suffer it to remain in the sac for hours or even days.

"No kind of food passed through the contracted cardia until the sac above it was quite distended, nor did he until then attempt to use any voluntary exertion as experience had taught him that previous efforts were ineffectual.

"At dissection, the œsophagus was found forming a sac or pouch reaching from two inches below the pharynx to the cardia. It contained by measurement two full quarts. The cardiac orifice was found pervious but much contracted.

"The poor sufferer had been examined by Sir Astley Paston Cooper, also by most of the medical men of this neighborhood, but he derived no benefit from the treatment recommended." At Sir Astley Cooper's suggestion, it was treated by the passage of bougies. Purton continues: "On withdrawing the probang, I was a good deal alarmed by the degree of force by which it was retained fearing lest the cardiac orifice might be lacerated. By gradual, but considerable repulsive force being used, it was at length withdrawn, and, on its passing the orifice, it made a report so loud as to alarm the bystanders."

Subsequent writers have added nothing to the description. None have shown a better dramatic sense.

The next report was by Hanney in 1833, in the *Edinburgh Medical and Surgical Journal*.

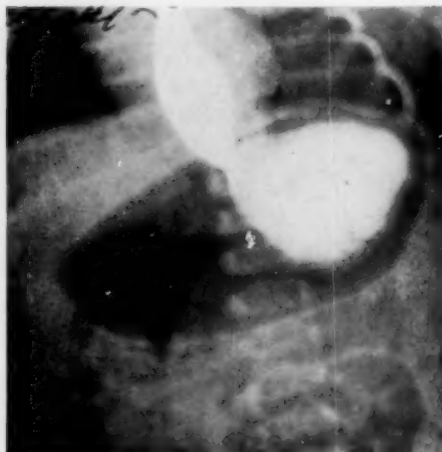


FIG. 1.—X-ray of infant which shows the opaque meal has entered the first part of stomach. Normal cardiac orifice dilated œsophagus. The meal was immediately rejected by a violent contraction of œsophagus.



FIG. 2.—Showing typical dilatation and narrowed œsophagus at level of diaphragm. Opaque fluid has partially entered œsophagus. Case not operated upon.

There seems to have been some general interest in 1840, for three separate reports are to be found in that year by Rokitauský, Delle Chiago, Fano, and Lindau. M. Curveillier's atlas in 1843 a picture is shown illustrating the disease. By 1877 Zeuker and Ziemssen could collect reports of eighteen cases. Neuman's series of papers in 1900 give the first comprehensive discussion of the subject, symptoms, methods of diagnosis, pathology and treatment. He found, up to that time, seventy cases. They are discussed under the title "Ein fach gleichmässige Erweiterung der speiseröhre."

Following this case, reports appear rapidly in the medical journals, so that Theiding in 1921 collected 315.

Beyond this it is unnecessary to go, to show that the disease is frequent enough to be important as well as interesting. It is not far from the truth to say that next to cancer it is the commonest disease of the œsophagus.

By idiopathic dilatation of the œsophagus is meant a considerable dilata-

## IDIOPATHIC DILATATION OF ŒSOPHAGUS

tion of the organ without an anatomical stenosis, but associated with difficulty in the passage of food into the stomach.

It is quite probable, in fact almost certain, that more than one pathological entity has been included in the list, and this has no doubt confused the picture. It would seem slightly probable, for instance, that a new-born infant suffering from violent vomiting in which the fluoroscopic examination shows the food to pass down the œsophagus into the fundus of the stomach only to be rejected by a violent contraction, first of the stomach and then of the œsophagus, and where the œsophagus shows marked peristalsis, is not the same disease as is shown in an adult suffering from an inability to swallow food, where a widely dilated and elongated œsophagus is seen; and there is no peristalsis.

There are also unquestionable instances where in sensitive individuals



FIG. 3.—Case J. S.—Pre-operative showing dilated œsophagus entrance of opaque meal.



FIG. 4.—Same case. Post operative. Œsophagus more upright, fluid opaque meal passing through cardia.

emotional disturbances are followed by a temporary or even momentary inability to swallow.

More difficult it is to reconcile those cases which show a very similar appearance under the fluoroscope, yet in the one, the œsophagus fills like a bag, and in the other shows marked or excessive peristalsis. In the author's experience these latter are rare, and though thickening of the muscle is found, peristalsis is seldom seen.

It is almost necessary to review the rather complicated anatomy and physiology of the œsophagus to be in a position to appreciate the effect of alterations.

This description is taken largely from Von Bergman and Staehlm's *Handbuch der Inneren Med.*, 1926; Abel's *Œsophageal Obstruction*; Müller die Lebensnerven and Kuntz' *Anatomy of the Nervous System*.

The œsophagus is a muscular tube extending from the inferior constrictor muscle of the pharynx to the cardia of the stomach. The lower boundary, which is important for this subject, is well marked. On the left side the œsophagus wall makes a sharp



angle at its junction with the stomach. That is termed the cardiac notch. On the mucosal surface the notch is marked by a fold of mucosa and submucosa called the cardiac valve, though of itself it has no valvular action. The right border of the œsophagus is continuous with the lesser curvature of the stomach. The passage from the œsophagus to stomach is further marked by the change from the squamous epithelium of the œsophagus to the columnar of the stomach. The average length of the tube is 25 centimetres, though it varies from 5 to 10 centimetres from this. The diameter, empty, is from 2.3 centimetres at the cricoid cartilage to 2.6 or 3 centimetres at the widest. It is normally about 2.5 centimetres where it passes through the diaphragm.

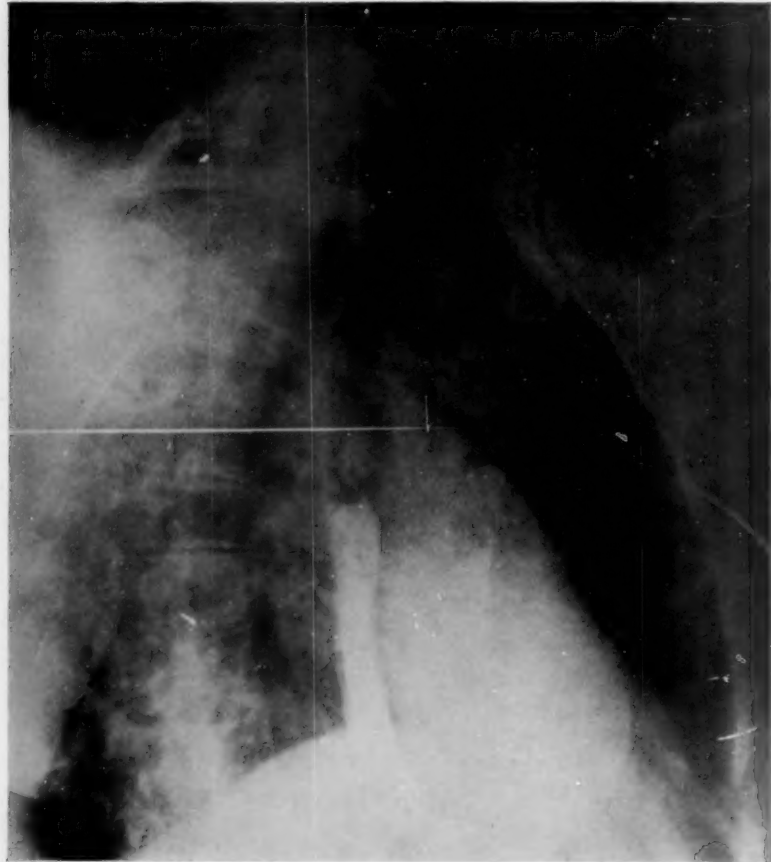


FIG. 5.—Case I. Four and one-half years after operation œsophagus narrow, normal width but still fills to 6 inches before opaque fluid begins to enter stomach.

The upper orifice is formed by the lower fibres of the inferior constrictor muscle and belong more to the pharynx than to the œsophagus. The anterior lip is thin and attached to the cricoid. The posterior lip is formed by a band of striped muscle which, on contraction, closes the opening against the cricoid. The muscular wall of the œsophagus consists of two layers, an outer longitudinal and an inner circular. The longitudinal fibres arise as a tendon, one quarter of an inch wide, from a vertical ridge on the back of the cricoid. This gives rise to two muscular bands which are at first on the front of the organ, then diverge to pass down each lateral aspect, and gradually become a continuous muscular coat.

This arrangement is overlapped by the inferior constrictor of the pharynx, or

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the superior sphincter of the œsophagus, arising from the thyroid and cricoid cartilages. The lower fibres from the cricoid form a circular bundle transitional between the striped fibres of the inferior constrictor of the pharynx, and the unstriped upper circular fibres of the œsophagus. These fibres when at rest are in a state of tonic contraction and maintain the upper opening closed.

A most important segment of the œsophagus from the point of view of the present study is the subdiaphragmatic portion. This is clear when it is realized that the obstruction to the passage of food always takes place at the level of the diaphragm. This section of the œsophagus is about 3 centimetres long. The left border, as has been stated, forms a sharp angle with the right border of the stomach. At its meeting the right border of the œsophagus is continuous in line with the lesser curve of the stomach.

The arrangement of fibres of the circular and longitudinal muscle is not entirely clear. There is general agreement that the cardiac sphincter is formed by a thickening of the circular fibres of the œsophagus to form a definite but not strong sphincter. The arrangement and termination of the longitudinal fibres is not so clear and yet it is essential to know the mechanism by which, during the act of swallowing, the cardia is opened. Forssell has pictured an arrangement of longitudinal fibres which, working together, act as a definite active dilator, and states: "The longitudinal muscle surrounding the cardia and the medial longitudinal bundle must, during a general contraction, act as a powerful dilator." Dissections of the longitudinal muscle layer show an arrangement of longitudinal fibres which bend sharply round the angle between the left border of the œsophagus and continue on into the outer layer of muscle on the right border of the stomach. This, together with a fixation of the right border of the œsophagus in the hiatus, shows at once that a general contraction of the longitudinal muscle somewhat as Forssell suggests must act as a dilator; while a paralysis or inhibition of the fibres will permit the circular fibres by the unopposed exertion of normal tone to close the cardia.

The contention (Chevalier Jackson) that the closure of the œsophagus is brought about by contraction of muscle bundles from the diaphragm has some anatomical support, but is none the less widely accepted on account, partly, of the difficulty in postulating a synchronized reflex for opening the cardia during swallowing, and from the fact that the hiatus is much larger than the œsophagus.

The nerve supply (taken largely by Kuntz anatomy of the nervous system) can only be briefly noted.

The œsophagus is supplied by both vagus and sympathetic nerves. The cervical parasympathetic supply is from the recurrent laryngeal. The two sides do not as a rule join branches. In the thorax, the left vagus passes down supplying the anterior surface, the right the posterior; but both cross over giving branches to both sides. Several branches from the left usually join branches from the right.

The sympathetic supply arises mainly from the inferior cervical. The lower portion also received branches from the thoracic portion of the sympathetic trunks. Some of these fibres go direct, others through the aortic plexus and through the great splanchnic nerve. The vagus and sympathetic form a plexus about the œsophagus.

The intrinsic nerve supply of the œsophagus consists, as in the rest of the intestinal tract, of the myenteric plexus situated between the longitudinal and circular muscle and the submucous plexus in the submucosa. These are generally known as Auerbach's and Meissner's plexuses. These two plexuses are connected by numerous strands of nerve fibres and include both fibres belonging to the enteric nervous system and the termination of the parasympathetic from the vagus. The sympathetic fibres which enter the œsophagus do not end around the nerve ganglia of Auerbach's plexus, but terminate directly in the tissue which they enervate. There is no clear anatomical evidence that the muscles are supplied by sympathetic fibres. The difficulty is to distinguish sympathetic fibres going to blood vessels from those that possibly supply the muscles of the œsophagus.

From the standpoint of this paper the only physiological interest is the act of swallowing.

The description is drawn largely from *Handbuch der Normalen und Pathologischen Physiologie*.

There have been three main theories relative to the passage of food through the œsophagus. First that it passed by peristaltic action; second that it is squirted by the action of the pharyngeal muscles through a rigidly held tube; and third that it passes through, in men, by gravity and by its weight overcomes the cardiac sphincter. This latter theory is of particular interest as it affects the understanding of the mechanics of idiopathic dilatation.

It can readily be shown that all three play a part. It is easily understood that there is a squirt action of the pharyngeal muscle constrictors, but that both the peristaltic action and the weight of the food play a part, is made clear, when the rates of passage as between fluid, semifluid and solid, are compared in the upright and the head-down position. In the upright position, fluid passes almost continuously into the stomach through a rigidly held œsophagus and an open cardia, semifluid almost the same but more slowly, while solid food takes an appreciable time and can be seen to pass as a Bolus as by a peristaltic wave. In the reversed position a single swallow stays in the upper end of the œsophagus and successive swallows gradually fill the tube toward the cardia, while solid food is still propelled as by a peristaltic wave into the stomach. The observation that fluid, in men in the upright position, flows by gravity through the œsophagus into the stomach presupposes the fact that the cardia is held open and offers no opposition to its passage.

The act of swallowing though initiated as a voluntary act becomes, during its execution, the swallowing reflex. As has been mentioned, the œsophagus is supplied by both vagus and sym-



FIG. 6.—X-ray of dog's œsophagus ten days after cutting of both vagi. No food entered stomach. (Esophagus widely dilated and filled with water and food.

pathetic nerves, but what part the sympathetic plays is not definitely known and the usual antagonism of the para and sympathetic has not been demonstrated. The matter is further complicated because the vagus holds both inhibitory and motor fibres, nor can a peristaltic wave be initiated by stimulation of the œsophagus at any one point as it can in other parts of the intestine. Stimulation of the central end of a divided vagus while the other is intact results not in peristaltic waves but a contraction of the whole muscles. The peristaltic waves are none the less controlled by the extrinsic nerves, and the orderly sequence of the movements of the swallowing reflex are regulated through a medullary centre.



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Further, respiration is necessarily inhibited during swallowing. It has not been demonstrated that the intrinsic neurons play any part in the swallowing reflex.

Understanding of the cardiac control is confronted with the same difficulty in that the vagus and sympathetic nerves contain both motor and inhibitory fibres and the response to stimulation varies (Carlson) with the strength of stimulation and the state of tonus in the muscles, if at the moment of stimulation the muscle is relaxed, vagus stimulation results in opening. It has been seen that there is reason to believe that this is an active opening of the cardiac orifice not merely a relaxation or inhibition of a closed sphincter.

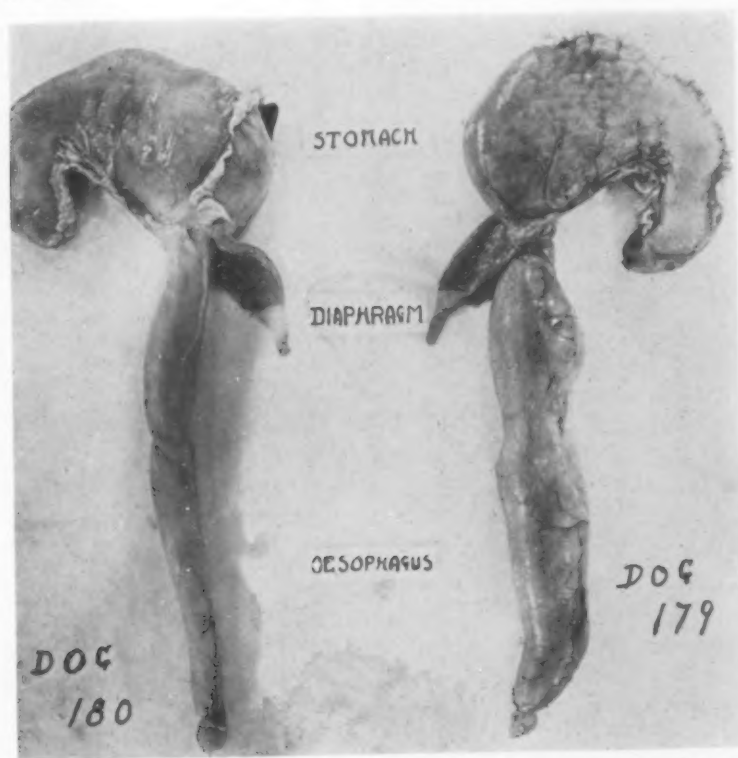


FIG. 7.—Photographs of two dogs' œsophagi after cutting both vagi. Shows paralytic dilatation. Normal cardia. No food entered stomach till death.

*Pathological state.*—As to the gross appearance of the œsophagus there is general agreement with no greater variation than would be expected between specimens. There is found in varying degrees both dilatation and elongation of the œsophagus. The dilatation begins at the upper end and gradually increases in the lower third. It may reach its maximum width in its middle portion and gradually taper to the hiatus of the diaphragm, or it may be pear-shape with its maximum diameter immediately above the diaphragm or it may be S-shape with the dilated œsophagus lying over the upper surface of the right diaphragm. These variations are differences of degree and are the expression of the degree of elongation as well as dilatation.

At the diaphragmatic end the œsophagus is almost invariably normal in diameter and the subdiaphragmatic portion is variously described as normal,

small, or pencil-like. It is this subdiaphragmatic portion which is of the greatest interest.

Out of 104 cases seen at operation or post-mortem (Bull) fifty-two were described as normal, and fifty-two as altered. Of the fifty-two altered, in the great majority the description suggests what has been found in each case examined by the author, namely, the dilated cesophagus extends to the diaphragm; but the subdiaphragmatic portion is small and pencil-like; in

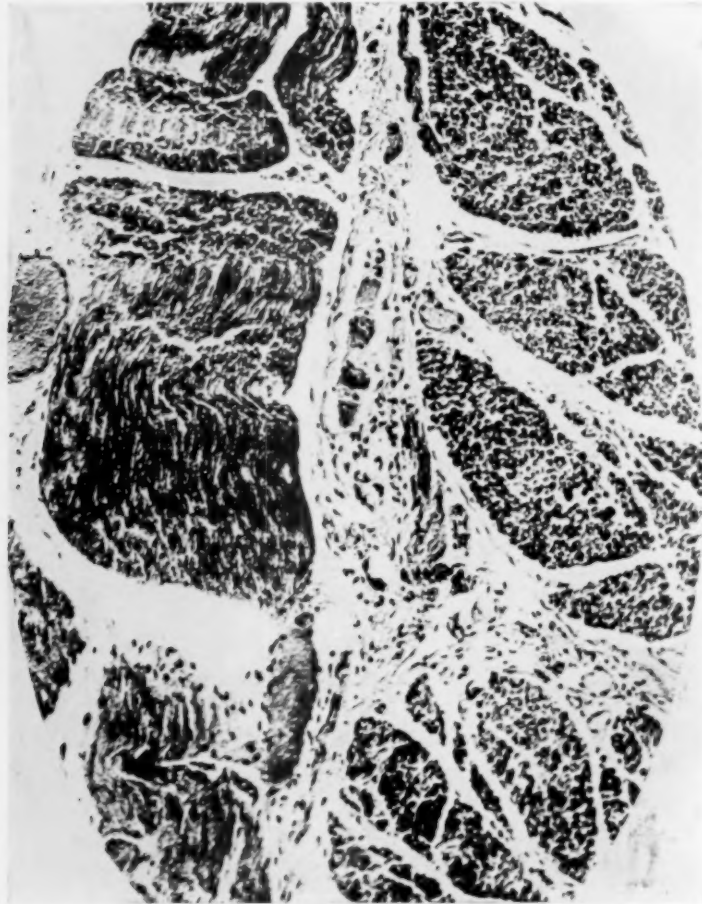


FIG. 8.—Microphotograph showing normal Auerbach plexus and contains four ganglia cells. (Rake.)

that sense contracted and the lumen narrowed, but with no hypertrophy or thickening of the muscular coat. In the dilated portion the muscular wall may be found as in Irwin Moores' careful description of three cases either of normal thickness, thinner than normal or abnormally thick from hypertrophy of the muscular coat and inflammatory thickening of the mucous membrane. The lining mucosa may be smooth, but is often ulcerated and the submucosa thickened and infiltrated.

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The hypertrophy of the muscular wall is mostly in the circular fibres. A thickened wall is rare but known as two of Moores' cases. (Illustrations taken from Moores' paper.)

In all of the five cases observed either at post-mortem or in the operating room, the subdiaphragmatic portion of the Œsophagus was distinctly smaller than the normal 2.5 centimetres. The organ appeared as a small round cord in one case about 1 centimetre in diameter, in one nearly 2 centimetres. The muscular wall of this portion was in none thickened, and in two distinctly thin, thinner than the corresponding muscular coat of the stomach. This was in marked contrast to the dilated Œsophageal wall immediately above the diaphragm. In each of this small number of cases, the Œsophagus immediately above the diaphragm was greatly dilated and lay over on the upper surface of the right diaphragm. The contraction from a diameter of 5 to 6 centimetres immediately above to the small subdiaphragmatic portion (in one case, 1 centimetre) was abrupt and took place at the level of the diaphragm. The hiatus was in each case quite wide and could not actually obstruct the Œsophagus, though the appearance of a kink at this level was insistent, both from the enormous difference in diameter of the two portions and the abrupt change in direction in the lumen of the Œsophagus.

There was in all a complete absence of hypertrophy of the muscular coat. In one the mucosa was ulcerated so that the tearing through of the muscular coat during the Heller operation resulted in an opening into the Œsophagus. The tissue was so friable as not to hold a suture.

Examination under the fluoroscope in each case gave the same appearance. The fluid drink entered the Œsophagus by the action of the pharyngeal muscles, fell straight down to the level of the diaphragm and then filled, from the bottom, to show a fluid level of varying height according to the quantity taken. There was no vestige of peristalsis. At the time of examination in this group, no fluid entered the stomach, in some others where the opportunity to confirm the observation was not given by operation, that is, in the lesser degrees, some fluid began to enter after a head pressure of from 10 to 12 centimetres was reached. Then fluid began to trickle in a fine stream into the stomach. In these which were of lesser severity, the dilatation of the Œsophagus was not so great, nor did the Œsophagus lie over on the right half of the diaphragm.

The fluid head could therefore exert its force on the closed cardia, while in the more widely dilated and elongated cases it seemed the greater the weight of fluid the more firmly was the cardia closed.

In some instances the capacity of the Œsophagus is enormous up to 1, 2 or even 3 litres, with a circumference up to 30 centimetres. It is noteworthy, as has been repeatedly recorded, that the dilatation in this disease reaches a far greater degree than is ever seen in mechanical obstruction by neoplasm or scar. One objection to the theory of a primary atony has always been the presence of an hypertrophied muscle in the dilated portion of the stomach and this has been held by Starck to exclude the possibility on the ground



that a paretic muscle does not hypertrophy; but as Chizzola points out that does not dispose of the case.

First there are the pseudo-hypertrophies associated with loss of power. There is the thickening of the wall apart from the muscular thickening, there is the analogy of the megacolon with hypertrophy and contraction but no advance of the contents and there is, above all, the fact that in the great majority of cases seen, no peristalsis can be seen under the fluoroscope so that while there may be contraction it may well have lost its coördinated sequence.

There has been great difficulty also in interpreting the experimental evidence of the cardiac innervation. Many seemingly contradictory reports on the evidence of vagus and sympathetic stimulation are found; but the main trend of evidence points to the conclusion that there is both vagal and sym-

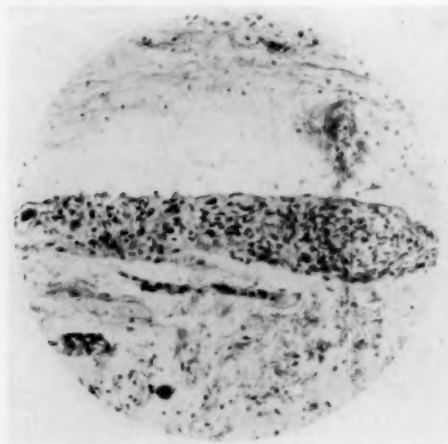


FIG. 9.—Microphotograph showing diseased plexus. Nerve fibres, replacement fibrosis but no ganglion cells. (Rake.)

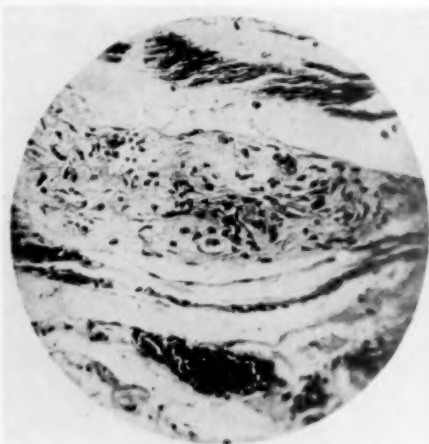


FIG. 10.—Microphotograph from Case II showing changes described by Rake.

pathetic influence and that in general the action is comparable to that found elsewhere in the intestine and this in spite of the fact that peristalsis cannot be initiated by stimulation of one part of the œsophagus.

There is anatomical ground for believing that atony of the longitudinal muscle must result in an inability to open the cardia and that there a break in the parasympathetic paths would result in a loss of tone in the œsophagus permitting dilatation and an inability to open the cardia in rhythm with the swallowing reflex.

Ever recurring in the writings is the difference of opinion as between a primary spasm of the cardia and secondary dilatation of the œsophagus as believed by Miculicz; and an achalasia or failure to open as originally suggested by Meltzer. Against the principle of primary spasm of the circular muscle of the subdiaphragmatic portion of the œsophagus, it is always argued first that an obvious stenosis never results in a dilatation of anything like the degree usually found in idiopathic dilatation; second, that there is

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never found any serious opposition to the passage of sounds, not more than would be found in the tonic closure of the unopposed circular fibres.

This is supported by the behavior of ingested fluid under the fluoroscope; third, that there is rarely found any hypertrophy of the circular muscle fibres which form the sphincter.

Anatomically, as shown by Forssell, and easily to be confirmed by dissection, there is an adequate muscular arrangement of the longitudinal fibres to open the cardiac orifice in rhythm with the swallowing reflex. It has been noted, and the evidence given for the belief, that fluids flow through the œsophagus into the stomach largely by gravity in the presence of an actively opened cardia and that this opening is accomplished by means of the contraction of the longitudinal muscles. If this be true then Kraus's theory gathers weight that the dilatation of the œsophagus and the closure of the cardia are brought about by some failure in the vagus path, by which the œsophagus becomes atonic, dilated and elongated; that this is necessarily accompanied by a loss of ability to actively open the cardia which remains closed by the tonic contraction of the circular sphincter fibres. This seems to the writer to be in accordance with the observed cases. Bougies pass with little or no opposition into the stomach.

Under the fluoroscope in the less severe degrees of the disease, fluid can be seen to fill the œsophagus to form a head, and then pass into the stomach as if the weight of fluid had forced the weak sphincter. In the more severe degrees this does not take place and in these there is noted a marked elongation of the œsophagus which lies like a sac over the right half of the diaphragm. In such instances the head of fluid cannot act to a mechanical advantage, but on the contrary the greater the filling the more marked the kinking of the œsophagus at the diaphragmatic level. Kraus's theory is supported by certain pathologic and experimental evidence.

His own case, where the vagi were found degenerated, has remained the only instance where a marked degenerative change has been demonstrated.

Cutting of the vagi as Langley and many others proved has confirmed results in an immediate loss of power to swallow fluid or solid food. This is accompanied by a rapid dilatation of the œsophagus and a closure of the cardia which remains permanent till death. Tamiya and other workers with him state that the cutting of one vagus results in a temporary loss of ability to swallow. Owing to the great difficulty in keeping animals alive after section of both vagi, Tamiya injected small quantities of arsenic into the vagi in the neck and stated that they produced more or less stoppage of the food according as the nerves were more or less degenerated. The writer has not been able to confirm this; all the animals either swallowed in a fairly normal way or failed to swallow at all.

There is no doubt that section of the vagi will produce a state superficially like that of idiopathic dilatation, yet it cannot be accepted as an explanation,

for it is accompanied by such general disturbance that it is extremely difficult to keep the animals alive. Such general disturbances are notably absent in the disease.

Very remarkable confirmation of Kraus's theory is given by the exceedingly important observations by Rake who found, and first reported, in 1927, a degeneration of Auerbach's plexus in the lower end of the œsophagus in three post-mortem specimens. Since then he has found the same changes in every instance, some fifteen, where he has had an opportunity to examine the sections. In one such case reported by the writer the changes were not recognized. Doctor Rake has subsequently examined this material and shown that similar changes are present. The accompanying illustrations demonstrate this conclusively. (Figs. 9 and 10.)

This offers a means of explaining a break in the vagal paths which may be localized to the cardiac portion or may extend for a varying extent up the wall of the organ.

Little need be said regarding the clinical picture. Purton's original description stands remarkably for the typical picture. To his means of diagnosis has been added the fluoroscopic examination which permits the recognition of many instances of the disease of lesser degree. The diagnosis is usually not difficult; the long history with remissions of symptoms, the character of the regurgitated food, the capacity of the œsophagus and lastly the characteristic appearance under the fluoroscope have long been known.

The cases here reported are typical in every way; and the interest or justification for reporting four patients operated upon lies in the fact that the operation proposed is based on what is believed to be the proper understanding of the pathologic physiology.

It is easy and safe to carry out and is based on an effort to take advantage of the mechanical state of the œsophagus and cardiac sphincter which results from the disease. The whole of the previous part of the paper is a tedious effort perhaps to build up the background of anatomy, physiology and pathology on which the operation is founded.

The lines of treatment have almost invariably followed one or two plans. First some form of dilatation of the cardiac sphincter either by the fingers through the stomach from below or by a dilator passed down the œsophagus. These latter have varied from Purton's probang to Plummer's hydrostatic bag. Of reports of treatment by this means, undoubtedly the most impressive are those of Plummer and Vinson based on a very large series of cases. Plummer in 1912 reported ninety-one cases treated by dilatation with seventy-three relieved of the dysphagia.

It is not the writer's intention to dispute in any way these records; similar series are published by Hurst and others. Naturally any operative treatment will be reserved for the intractable case. None the less it is difficult to understand, in view of the temporary effect of dilating other sphincters in more accessible positions, how such an effect is permanent.



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Also it cannot be impressed too strongly that there is danger in attempting to stretch a narrow, thin-walled and often ulcerated tube, more especially when such a dilatation, whether from above or below, must be done blindly. It is true that some of this danger can be avoided by previous washing of the dilated œsophagus and regular emptying of its fermented contents. This alone, synchronous with the subsidence of the inflammation and the healing of the ulceration, is enough to reestablish the ability to swallow except in those instances where the elongation as well as dilatation is marked.

Of the operative treatment there have been two types.—First, the anastomosis of the dilated œsophagus to the fundus of the stomach, such as has been successfully practised by Bull and others; and that proposed by Heller on the analogy of the infantile pyloric stenosis and consisting in cutting through the circular sphincter muscle of the subdiaphragmatic œsophagus, but not entering the lumen of the organ. The objection to the first is its danger, for the œsophagus is not good tissue to suture and if ulcerated and inflamed, may release highly virulent organisms into the mediastinum. The objection to the Heller operation will develop in the course of the description of the operation here proposed and carried out successfully in three cases.

In the first case operated upon, the Heller procedure was carried out, but in order to get a good exposure the hiatus in the diaphragm was enlarged, the dilated portion of the œsophagus brought down for about one inch below the diaphragm, and the circular muscle of the subdiaphragmatic portion of the œsophagus cut through until the submucosa bulged as is usual in the Frédet Ramstedt operation on the pylorus. The result was entirely satisfactory. The patient who previously was living by passing a stomach tube three times a day, was able to swallow fluids when sitting up.

In the second case, one of those here reported, a similar operation was attempted, but on scraping through the circular muscle layer the lumen of the œsophagus was entered. There was no mucosa or submucosa. The opening not more than a quarter of an inch was immediately sutured and reinforced by an omental pad, but the patient died from an infection of the mediastinum and at post-mortem a large opening in the œsophagus was found. This opening extended well above the point of injury as if the wall had melted under the infection.

Following this disaster the mechanics of the operation were reviewed. It seemed obvious that in the first instance the cutting of the thin muscular layer had really accomplished little or nothing, but what had been done was to bring down and to straighten out the elongated œsophagus so that the fluid accumulating in the œsophagus in the upright position could act to a mechanical advantage and so force the very slight opposition at the cardia. This in fact could be seen to happen under the fluoroscope. The œsophagus filled up to six inches above the diaphragm, then the opposition gave out and the fluid entered the stomach.

In the next three cases (one previously reported) it was deliberately planned to limit the procedure to the enlargement of the opening in the

diaphragm, the bringing down and therefore the straightening out of the elongated œsophagus without touching the muscle as in the Heller operation, or opening the lumen as when an anastomosis is done. The procedure is easily done and should be safe.

The idea of enlarging the opening in the diaphragm has been proposed before, first so far as I know, by Anthony Bassler in 1914 under the influence of Chevalier Jackson's contention that the closure of the cardia is brought about by muscular bands derived from the diaphragm. The procedure carried out in the three cases reported is as follows:

An incision as described by Marwedel in 1910, was made in the left paramedial line beginning about 2 inches above the xiphoid. The muscles are cleared from the cartilages of the seventh, eighth, and ninth ribs and pushed laterally. The cartilage of the seventh rib is cut through at the junction with the sternum, care being taken not to enter the pleura or pericardium. The cartilages of the seventh, eighth, and ninth ribs are cut through at the costochondral junction. In this way a flap consisting of rib cartilages and diaphragm can be retracted laterally exposing the left lobe of the liver. The coronary ligament of the liver is then cut as far as may be necessary to turn the left lobe of the liver down and to the right. This brings one to the fundus of the stomach and the subdiaphragmatic portion of the œsophagus. Loose areolar tissue is cleared away, a large vein crossing the crura ligated and cut. The opening through the diaphragm enlarged by cutting the crura. The fingers are then inserted through this opening and the œsophagus, which lies well over towards the right, freed from surrounding areolar tissue and brought down through the opening for 2 inches or more. In order to do this the right vagus nerve may have to be cut, but since the vagi form a plexus about the lower œsophagus this may be done without danger.

The edges of the enlarged hiatus are then sutured to the thickened muscular wall of the dilated portion of the œsophagus and the wound closed. This procedure has been followed in three cases as the appended case reports will show.

Subsequent examination under the fluoroscope shows that fluid enters the œsophagus as before, fills to a varying point 4 to 6 inches above the diaphragm and then begins to trickle through the narrowed cardia into the stomach.

It is necessary only that food should be finely divided and well mixed with fluid. After a meal it is advisable to take a quantity of water to prevent remnants of food remaining in the lower œsophagus.

#### CASE REPORTS

CASE I.—Miss J. P., aged forty-five. Complaints of difficulty in swallowing. Onset sudden nine months previous to admission, with vomiting all food. Sensation of food sticking under the sternum with choking sensation. This has continued ever since. Relieved by regurgitation of food. Has gradually got worse. Feels hungry all the time and has lost weight.

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Her weight nine months ago was 170 pounds, now 121. A loss of 49 pounds. Feels weak from loss of food.

Personal and family history have no bearing on her present illness except that previous to the onset of her present symptoms there had been no gastro-intestinal disturbances.

*Examination.*—No ability to swallow, regurgitates almost all food, some fluids pass. General examination shows nothing abnormal. Œsophagoscopy examination reveals a somewhat æsthetic pharynx, great dilatation of the lower Œsophagus, some greenish fluid content. Œsophageal wall smooth. No ulceration, no bleeding.

*Fluoroscopic examination* (films destroyed) shows a greatly distended Œsophagus. The dilated portion lying over on the right diaphragm. No visible peristalsis, six-hour retention of barium drink, none has entered the stomach. The examination was repeated under atropine and a similar picture obtained. The height of the column of barium retained was about 6 inches. Following the atropine she thought she retained food better, but no such improvement could be demonstrated. Began night and morning feeding by tube, mid-day meal of fluid attempted without tube. No improvement. Benzyl benzoate, adrenalin, ephedrin all tried without effect. Protein sensitization tests are all negative. Regurgitated the noon meal; tube feeding retained. Ergotamine tried without benefit. February, 1926, transferred to surgery.

*Operation* February 28, 1926. Heller extramucosal cardioplasty. Marwedal's incision. The subdiaphragmatic portion of the Œsophagus was found to be three-quarter inch in diameter. The wall was not hypertrophied. The wall over the cardiac end of the stomach incised down to the submucosa and this incision was extended upward over the lower end of the Œsophagus. It seemed satisfactory up to this point, when without obvious reason a small leak was observed in the Œsophagus. This quickly enlarged to a hole about one-quarter inch in diameter as if the mucosa was either ulcerated or very soft. The opening was sutured and reinforced by a layer of peritoneal tissue. Over this was sutured a wedge of omentum. Wound closed with drain to the site of the tear. She died March 5, 1926, of peritonitis, mediastinitis and pericarditis, due to a leak at the suture line.

At autopsy there was found a large ragged hole in the Œsophagus extending three centimetres above the diaphragm. Sections showed an ulceration of edges and extensive inflammatory infiltration.

Doctor Rake has examined sections and reports findings in accordance with those described in his publication. Microphotographs are shown in Figs. 9 and 10.

*CASE II.*—Miss K. B., aged fifty years. Admitted November, 1926, complaining of pain and difficulty in swallowing, regurgitation of food and loss of weight. Onset of symptoms five years ago, with difficulty in swallowing and pain in the lower end of the sternum. Difficulty gradually increased until unable to swallow any food without pain and great difficulty. She takes from one to two hours to a meal, and eats alone because, in her efforts, food is as likely to regurgitate as to go down. She takes fluid till the Œsophagus feels full, then holds the nose, takes a breath, throws back her head and forces down. She accompanies the meal with large quantities of water.

X-ray examination, plate 2, shows marked dilatation of the Œsophagus, with only small quantities passing down the Œsophagus. A drink of barium and water passed more readily.

She had been under medical treatment for varying periods. Had had atropine and dilatation with hydrostatic bag dilator. Had had periods of tube feeding and had learned to pass stomach tube herself.

An Œsophagoplasty was done November 15, 1926, Marwedal incision. The subdiaphragmatic portion of the Œsophagus was found to be a small round cord about one-half inch in diameter. The hiatus was enlarged by cutting forward and to the right. The dilated portion of Œsophagus brought down for nearly two inches and

sutured to the edge of the enlarged hiatus. It was fully two inches in diameter at this point. The abdomen was closed without drainage.

From the time of the operation till the present, she has been able to swallow food normally, provided it is finely divided and well mixed with water. She has regained her weight and strength.

X-ray plates (Fig. 5) show the fluoroscopic picture nearly four and one-half years after operation.

The œsophagus has regained a nearly normal size, but still requires a 6-inch head of fluid column before food enters stomach.

CASE III.—Mrs. B. McD., aged fifty-eight years, May, 1926. Difficulty in swallowing began about one year ago, more with solids than liquids. Takes food till she feels full up. Then by forceful efforts works the food down. Sometimes during these efforts she regurgitates. She then rests, fills the œsophagus again and again forces it onward. The œsophagoscope reveals a dilated thoracic œsophagus and a closed cardia which was found to grip around a bougie.

Since 1926 she has had more and more difficulty in swallowing, with regurgitation of food. In December, 1928, contracted influenza and was extremely ill, and could swallow no food. At this time tube feeding was instituted. She quickly learned to pass her own tube and has continued ever since. She has lost 80 pounds in the past three years.

*Operation* May 29, 1929. Œsophagoplasty. Marwedel's incision. The subdiaphragmatic portion of the œsophagus was found to be about 2 centimetres in diameter. The wall was not thickened. The opening in the diaphragm was enlarged, the dilated portion of the œsophagus brought down. At this point it was 2 inches in diameter and not notably thickened. In order to bring it down the right vagus was cut. Immediately following operation she was able to swallow normally and she has continued to be able to do so. No films available.

CASE IV.—J. S., aged fifty-eight.

*History of the present illness.*—About one year previous to the operation he began to suffer difficulty in swallowing and what he took to be vomiting.

The onset was sudden but the course intermittent. Gradually the difficulty in swallowing became more severe and he regurgitated quantities of food mixed with mucus.

*Personal history.*—The patient has been known to be diabetic for five years. The diabetes in moderate degree requires to take insulin. He used alcohol to excess. The Wassermann was negative.

*Operation.*—Marwedel's incision. The subdiaphragmatic portion of the œsophagus was found to be about three-quarter inch in diameter. The hiatus was enlarged, the œsophagus freed and brought down 2 inches below the diaphragm. At this level the dilated portion was about 2 inches in diameter, the wall definitely thickened. The right vagus nerve and a branch of it were cut to allow the œsophagus to be brought through. Sutured to the edges of the opening.

Following this he swallowed liquid food freely. X-ray before leaving hospital shows the œsophagus as before, but when the head of fluid reaches about half way up the chest fluid begins to enter the stomach.

He returned home and was well until he had a violent attack of vomiting lasting three days. Reentered the hospital.

He vomited large quantities of coffee ground vomitus when taking no fluid by mouth. Stomach washing demonstrated that the vomitus was from the stomach and that fluid entered the stomach.

His blood sugar rare and he showed acetone in urine. Under the control of the diabetes and stomach washing the vomiting gradually ceased and he began to take food again. X-ray plates 3 and 4 demonstrate the condition of the œsophagus still dilated



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but fluid enters stomach under the pressure of a head of fluid of 6 inches. Water following the meal carries it through.

He lives on finely divided food mixed with fluid and followed by water.

DISCUSSION.—DR. LEONARD FREEMAN (Denver, Colorado) said there seems to be two forms, or two reasons why swallowing is difficult in dilatation of the œsophagus: One is the fact that it is a cardia spasm, and the other is the fact that the cardia seems to be too long for the room in the chest allotted to it so it becomes convoluted. And the difficulty in swallowing is not always due to the fact that the cardia spasm is present, because it is not at all present in these cases. Kummell has called attention to some where the mere fact that the length of the œsophagus was convoluted prevented swallowing.

Any muscle that has not any proper point of attachment, or that is too long for its point of attachment, does not work properly. That opens up the idea that Doctor Scrimger has so accentuated, that the œsophagus may be shortened by pulling it down into the abdominal cavity; or, as first suggested by Pribram but not carried out by him, it may be shortened by pulling it up into the neck.

In 1923 the speaker read a paper on that subject before this Association in which he recounted the results of an operation he did in 1902, twenty years before, upon a man who was unable to swallow because of a supposed cardia spasm. He cut down the neck and found a dilatation of the œsophagus. By passing the finger into the thorax through the wound in the neck, he was able to loosen the œsophagus, and then he pulled it up into the neck, getting perhaps a fold of œsophagus that was 2 or 3 inches in length. After reflection he decided to invaginate the upper end of the œsophagus into the lower. This he proceeded to do, thus shortening the œsophagus and reducing the cardia over that portion that was invaginated. He then closed the wound in the neck.

It was a simple operation. No infection—it healed nicely. The man was relieved immediately. That relief lasted for twenty years. It would seem that if one adopts this method of shortening the œsophagus that it is easier and simpler to do from a wound in the neck and invaginating the œsophagus into itself, than to do it from an elaborate wound and attempt to pull the œsophagus down into the abdominal cavity.

DOCTOR SCRIMGER rejoined that the very severe case is produced by the kink. The mechanics of the diaphragm present a picture quite different in a lesser degree of severity, where the œsophagus comes down to a long point at which, as it fills up, there is a steady trickle that goes into the stomach. In the severe cases, where the œsophagus has elongated over into the diaphragm, the more you put into it, it seems, the more it is obstructed. Bringing down the œsophagus through the diaphragm is quite easy. The approach is made very simple by the so-called Marwedel incision, turning down the left side of the liver, and then the œsophagus can be brought up to the wound, as can the pyloric end of the stomach.

## THE PYLORIC SPHINCTER AND DUODENAL ULCER

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CHRONIC duodenal ulcer continues to occur without explanation or apology; and when we try to investigate its associated phenomena we find new wonders. The incidence of ulcer is increasing and we know of no preventive measures. All is not serene among those who treat the disease. It may get well without any treatment, but of this we have grave doubt particularly as it applies to chronic ulceration. Medical treatment undoubtedly can control symptoms but in our experience recurrence follows remission of treatment in the same fashion it does in the natural course of the disease with the exception that the period of absent symptoms is longer. Once established there seems to be an inherent tendency to duodenal ulceration or to the underlying disturbance of which it is a sequel, so that, for a time, it may be held in abeyance, but reactivity of the lesion is resumed when the methods of control are withdrawn. The results of surgical treatment in competent hands have been highly satisfactory. The selection of patients for operation plays a large part in beneficial results. Gastro-enterostomy for chronic duodenal ulcer especially in the presence of obstruction is one of the most satisfactory operations in surgery. Improved diagnostic methods, especially the X-ray and the widespread familiarity with the symptoms of ulcer have led to earlier recognition. Today, duodenal ulcer is operated on earlier by many surgeons and before the proverbial nine medical cures. The results in these early cases from gastro-enterostomy are not so highly satisfactory and the immediate good results seem to diminish as the post-operative period lengthens. The reason for this we do not know. Its investigation may uncover important therapeutic facts. We suspect that in these early operated ulcers with unsatisfactory results the state of pathologic physiology of which ulcer is a sequel is a temporary affair, which, when it spontaneously rights itself, leaves the patient with an unnecessary gastro-enterostomy. The latter then may give rise to digestive derangements and symptoms and actually may favor the development of a marginal ulcer. Medical treatment has its value. When properly and faithfully followed, it may, in many cases, control the condition until the tendency to ulceration disappears. The difficulties as we see them are that by no method can one select and eliminate the candidates for chronic duodenal ulcer and any process of selection by medical treatment must face the dire hazards of perforation and hæmorrhage. We cannot see the wisdom of partial gastrectomy for duodenal ulcer. We admit that the indiscriminate use of gastro-enterostomy for every case of duodenal ulcer produces results which leave the surgeon in a position difficult to defend. Gastro-enterostomy occupies a conservative surgical position. Within the last four

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years we have become more conservative but we still adhere to our belief that by means of operation the welfare of the patient is best served and safeguarded. In this time we have practiced a new surgical procedure but have not discarded gastro-enterostomy, which we reserve for those patients in whom certain definite indications are present only when the lesion is exposed at operation. There are certain striking differences between the functional behavior of the normal stomach as compared with the stomach of an individual who has a duodenal ulcer. The latter may be called pathologic physiology. It is generally ascribed to the disturbing influence of the ulcer. It gives rise to characteristic symptoms by which ulcer is recognized. We have adopted the view that such symptoms antedate the appearance of ulcer and that they signify a derangement of function of which ulcer is a sequel. The chronicity of ulcer and its tendency to recur after periods of remission depends upon the maintenance of perverted gastric function.

The secretory activity of the stomach is so adjusted that the quantity of gastric juice is directly proportional to the quantity of food, and the juice as it flows from the glands possesses a constant acidity. In the words of Pavlov: "The astonishing exactitude of the work of the glands: that which is demanded of them they furnish each time to a hairbreadth, no more and no less." In this normal scheme of things there is no necessity for a neutralizing mechanism to take care of excess acid since the juice, as it comes from the glands, has a constant acidity, about 0.5 per cent., and only enough is produced to maintain an optimal digestive concentration in the food mixture.

The stimuli for the secretion of acid originate from two separate sources. One, the more important, is the psychic stimulus which is initiated by the sight, smell, or taste of food. It gives rise to an outpouring of so-called appetite juice which is highly potent in digestive properties. This stimulus has been proven to reach the gastric glands by way of the vagi nerves. Pavlov showed that dogs in which the vagi are cut high up will not produce gastric juice after sham feeding. "Appetite spells gastric juice." The other stimulus, the lesser of the two, comes from the presence of food in the stomach.

Variations above normal in gastric secretion are most likely to ensue when the psychic stimulus is overactive or unduly prolonged beyond digestive requirements. The excessive acid so produced must be controlled by neutralization first, in order that digestion can proceed, and second to avoid injurious effects of highly concentrated acid on the gastric mucous membrane. Temporary and slight degrees of excessive acidity are probably controlled by an outpouring of mucus. However, the mucus of the stomach has only weak neutralizing properties. The pyloric mechanism is the main factor for control when for any reason gastric acidity shows a tendency to exceed normal limits. It seems more in keeping with facts to speak of the pyloric control of acidity rather than of the acid control of the pylorus. The pyloric sphincter in coordination with reverse peristalsis in the duodenum, upon demand, provides for regurgitation of duodenal contents into the stomach. This fluid, composed mainly of pancreatic juice, is the most alkaline in the body. Many

investigators have confirmed the finding of Boldyreff that duodenal regurgitation occurs so commonly that it may be called a natural phenomenon.

Thus, it would seem that the normal stomach under normal control produces a quantity of acid which is accurately regulated in keeping with digestive requirements and when, as the result of overacting stimuli, an excess of acid is formed, the control mechanism of duodenal regurgitation provides the factor of safety.

Quincke in 1889 observed a child with a gastrostomy and noted that during fasting the pylorus often remained open for ten minutes during which time bile and other intestinal fluids passed to and from the stomach. This so-called duodenal regurgitation was later studied by Boldyreff who concluded that it was a natural phenomenon and ascribed to it a regulatory rôle in the control of gastric acidity. The observation of Boldyreff has been widely confirmed and generally accepted but his theory as to the natural control of gastric acidity has been questioned by the results of recent experiments. The latter hold to the view that the normal stomach has an inherent ability to control its own acidity. But the stomach of an individual with duodenal ulcer does not exhibit normal function and there is a notable failure to control acidity. If what Pavlov states is true regarding the secretory behavior of the stomach, then the state of hyperacidity must result from an overproduction of acid, that is, beyond or independent of digestive requirements combined with failure of some mechanism whose purpose is the control by neutralization of excess acid. A number of investigators have made experiments on duodenal regurgitation in dogs by introducing into the stomach 200 cubic centimetres of 0.5 per cent. hydrochloric acid. They found that the regurgitation of duodenal fluid into the stomach is a constant occurrence and that the rate of neutralization of gastric acidity can be accurately measured. That antiperistalsis in the duodenum is the force behind regurgitation is indicated by the X-ray studies of Salmond. In 100 consecutive human cases he observed antiperistalsis in the duodenum in ninety-three. The actual regurgitation through the pylorus into the stomach he has been able to see in some twenty odd cases but this, he states, is difficult to detect. Intragastric pressure is normally below 10 centimetres of water while duodenal pressure is between 10 and 15 centimetres of water. In their clinical studies, Wright and Medes found that regurgitation of duodenal contents into the fasting stomach occurred in 100 per cent. of the cases and that it took place with special frequency as the stomach is emptied. The purpose of regurgitation obviously is to neutralize excess acid and in the process the pancreatic juice is the main factor. Hepatic bile is neutral in reaction and usually acid before reaching the intestines.

The division between stomach and duodenum is sharply defined anatomically and physiologically by the pyloric sphincter. Formerly it was thought that this muscular ring had much to do with the emptying of the stomach but in this it actually plays a small part unless by dysfunction or fibrous contraction a functional or mechanical obstruction exists.



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Text-books of anatomy refer to the pylorus as a local increment of circular muscle fibres. The importance of the pyloric sphincter as a separate anatomic and physiologic entity recently has received recognition. About five years ago when we became interested in the relationship between the pyloric sphincter and peptic ulcer one of us made dissections of the human stomach by removing the mucosa and submucosa. Observation of the exposed muscular coats demonstrated that the pyloric sphincter was a distinct muscular ring. In other dissections we found that the sphincteric muscular ring could be peeled off readily from the underlying submucosa to which it was only loosely attached. A true sphincter not only has the ability to contract, which is its most generally accepted function, but also to undergo active dilatation. In 1879 Rudinger described the dilator muscle of the pylorus; and Forrsell said that the pyloric sphincter has radial and circular muscle fibres which like the iris can diminish the lumen of the tube-shaped canal. The recent studies of Horton have been most interesting. He demonstrated that at the pylorus 50 to 55 per cent. of the longitudinal fibres which are continued down from the stomach, dip into the pyloric sphincter to take part in the formation of the sphincter and constitute the dilator muscle of the pylorus. The circular muscle fibres of the pylorus constitute four or five times more of the thickness of the sphincter than do the longitudinal fibres. From his studies he concluded that the pyloric sphincter is a complete sphincter, in which there is both a constrictor and dilator mechanism.

If it be true that the pyloric sphincter has a dual opposed musculature like a true sphincter then for purposes of coördinated function it must possess a double innervation whose nerve fibres cannot be solely vagal or sympathetic in origin but the innervation of the circular fibres must be derived from a source other than that for the dilator fibres. Researches on the innervation of the pyloric sphincter have not yielded concordant conclusions. For the ileocaecal sphincter, Elliott showed that the sympathetic is for contraction and the vagus for relaxation. In the general musculature of the stomach the vagus is motor. Since the only part of the pyloric sphincter formed from the general musculature of the stomach is by the longitudinal fibres which dip in to form the dilator muscle it seems logical to infer that vagal stimulation, unless too strongly opposed by contraction of the more powerful circular fibres, should cause active dilatation of the pyloric sphincter. The circular fibres of the sphincter are independent of the musculature of the stomach. In fact, according to Gaskell, the sphincters of the gastro-intestinal tract do not have a common origin with the enteric musculature but represent isolated remains of epidermal musculature. In accordance with this developmental theory Gaskell believed that the motor nerves for the constrictor fibres of the gastro-intestinal sphincters were derived from the true sympathetic nerves of the thoracico-lumbar outflow from the spinal cord. Carlson and Litt in the course of their studies on the reflex control of the pylorus state that mechanical or electrical stimulation of any visceral afferent nerve may induce a temporary spasm of the pylorus and that these reflexes persist after section of both vagi in the neck.

Therefore, it would seem that the main efferent paths are in the splanchnic nerves. They found that epinephrin (whose specific action is only on structures supplied by true sympathetic nerves) induces contraction of the pylorus. They conclude that the predominant reflexes from the viscera into these sphincters (cardiac and pyloric) under their experimental conditions, is motor, and if prolonged they became cardiospasms and pylorospasms.

From a study of the work of the above investigators we believe there is evidence to indicate that the constrictor fibres of the pyloric sphincter are supplied by the sympathetic and the dilator fibres by the vagal nerves. It also seems well established that regurgitation of duodenal contents into the stomach is a natural phenomenon whose purpose it is to neutralize gastric acidity when the latter for any reason is produced in excess of digestive requirements. The pyloric sphincter by its strategic position presides over and controls the mechanism of duodenal regurgitation.

Hyperacidity by which we mean a real excess of hydrochloric acid can arise only from an overactivity of the stimulus which produces normal acidity. The main pathways for this stimulus are the vagus nerves since section of these nerves produces a permanent reduction in gastric acidity. Temporary hyperacidity probably is of frequent occurrence and its control is by the safety mechanism of duodenal regurgitation. One of the characteristics associated with duodenal ulcer is persistent uncontrolled hyperacidity. By means of the acid-test meal, patients with duodenal ulcer have been shown to have inadequate or absent duodenal regurgitation. For this the fault seems to lie with the pyloric sphincter which through failure to open (achalasia) or because of spasm acts as a hindrance to the needed reflux of duodenal contents into the stomach. Is this disturbance of function secondary to and caused by the presence of duodenal ulcer? According to the views expressed by Hurst, the answer is in the affirmative. He also explains the symptomatology of ulcer on the basis of dysfunction of the pyloric sphincter. We are in agreement with the latter view but on the basis of our clinical experience and the researches of others we hold that the symptoms precede the appearance of ulcer and that such symptoms are the expressions of a disturbed physiology of which ulcer is a sequel. Every surgeon many times has had the experience of operating on a patient who exhibited the characteristic symptoms of ulcer but no ulcer by a most thorough search could be demonstrated. Such instances particularly occur when the history of ulcer has been one of short duration. These symptomatic ulcers are often cured by medical measures. Little wonder that Moynihan was led to remark: "The ulcer that cannot be demonstrated to the entire conviction of the onlooker does not exist." To the detriment of surgery we must admit that symptomatic ulcer has often been treated by gastroenterostomy. In these cases we have many times found the lesion in the appendix.

Most of the older work on the experimental production of peptic ulcer can be discarded. In our opinion the experiments of Mann by which he regularly produced typical peptic ulcers in dogs by his method of surgical duodenal drain-

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age establish beyond doubt the importance of acid as the paramount etiologic factor. In these experiments there are two other significant points. The ulcer did not occur in the duodenum but in the proximal end of the transplanted jejunum and the acidity of the stomach as shown by McCann remained unchanged. These findings indicate that acid is the main etiologic factor in the production of ulcer; that in the jejunum under the conditions of the experiment an ulcer may result from the action of normal gastric juice and that duodenal regurgitation normally is not required for the control of gastric acidity again confirming the views of Pavlov on the exactitude of gastric secretion. The experiments also do much to explain the occurrence of secondary ulceration after gastroenterostomy since this operation may permit unmodified gastric juice to come into direct contact with the jejunum.

Weiss and Guriarran cut the duodenum across below the exit of the bile and pancreatic ducts. The proximal end was united to the side of the lower ileum thus diverting the duodenal contents. The pylorus was then divided and the duodenal opening closed by suture. The efferent loop of the duodenum after the first step of the operation was united end-to-end to the pylorus. In each of the fifteen dogs so treated a typical chronic, sometimes perforating, ulcer developed in the duodenum several centimetres below the anastomosis. In these experiments they also found, as did McCann, that there was no change in gastric acidity from the pre-operative figures. In their opinion gastric acid is the chief etiologic factor in the development of ulcer and duodenal regurgitation is a protective mechanism which not only saves the mucous membrane from the harmful effects of hyperacidity but it also gives the needed protection against normal acidity. How does this experimental work apply to the human subject? Duodenal regurgitation occurs with such regularity in the normal stomach as to be considered a natural phenomenon. In patients with duodenal ulceration it has been demonstrated that regurgitation is either absent or deficient. Ulcer is not the cause of symptoms because typical symptoms so frequently occur in the absence of ulcer and during periods of symptomatic remission the ulcer is still present but is in a process of healing which has been verified by careful histologic studies although completely healed ulcers are extremely rare at the operating table. Those who have studied the progress of ulcers under medical treatment report that symptoms do not disappear until pylorospasm has been relieved. In the opinion of Hurst, with which we agree, the symptoms of ulcer are an expression of dysfunction of the pyloric sphincter. Gastroenterostomy is an experiment in physiology. In this operation the surgeon unknowingly puts to test the theory that acid is the chief etiologic factor in ulcer. The subsequent development of a marginal or jejunal ulcer is evidence of the fact that the jejunum is vulnerable to the action of normal or hyperacid gastric juice. If the anastomotic stoma is insufficient in size or develops a sphincteric mechanism it may prevent the entrance into the stomach of the neutralizing duodenal contents so that unmodified or hyperacid gastric juice is ejected directly into the jejunum where an ulcer develops at the site of contact as it did in the

duodenum. When a gastroenterostomy is made following the appearance of the ulcer after Mann's surgical duodenal drainage the original ulcer promptly heals but a new ulcer usually develops in the jejunum opposite the anastomosis. In patients with duodenal ulcer treated by gastroenterostomy and in whom symptoms were relieved Elman showed by means of the acid test meal that there was prompt and efficient neutralization of the acid.

It is our belief that in the development of duodenal ulcer two etiologic factors are at work, neither of which can cause the ulcer without the coöperation of the other. One is hyperacidity by which we mean an overproduction of acid. The other is spasm or achalasia of the pyloric sphincter. Hyperacidity no doubt occurs periodically in many individuals who never develop duodenal ulcer for the reason that they have an efficient safety mechanism in duodenal regurgitation. Likewise pylorospasm must be of frequent occurrence in many individuals particularly in those who harbor an intra-abdominal focus of infection. In these we often find the symptoms without the ulcer. But when there occurs the combination of the two factors, that is, hyperacidity and pylorospasm, the offspring of this mating is ulcer. We do not know the cause of hyperacidity. The stimulus which produces it comes down the vagus nerves. It is an exaggeration of the appetite or psychic phase of gastric secretion. Less do we know of means to control it. Perhaps complete mental and physical rest is the answer. Indeed, patients with duodenal ulcer often experience complete symptomatic relief when they are able to obtain physiologic rest. It is an important part of the medical treatment of ulcer. But life must go on and such treatment cannot be followed indefinitely. We know that pylorospasm is often a reflex from an intra-abdominal irritation. In this way chronic appendicitis or cholecystitis, the two most common foci of infection within the abdomen, may under proper conditions play a large part in the etiology of ulcer. Pylorospasm may also occur as a part of a general nervous disturbance which particularly affects structures supplied by sympathetic nerves and is manifested by sympathetic overactivity. The work of Crile along this line deserves serious consideration. He has advocated and practiced resection of the suprarenal glands for the cure of duodenal ulcer. Many observers have noted that duodenal ulcer usually selects for its host an individual of a characteristic constitutional type.

The active treatment of duodenal ulcer when carried out along rational lines especially with regard to etiologic factors, to be successful, must attain one important result, namely, the control of hyperacidity. In what better way can this be done than by restoration of the natural mechanism for neutralization? This may be accomplished in an indirect manner by gastroenterostomy. The results of this operation are not uniformly satisfactory when based on the experience of many surgeons. Careful selection of patients will improve the surgical results but what is to be done for those patients who fail to qualify for operation? Must they serve an apprenticeship under medical treatment before being admitted to the operating room?

Many surgeons hesitate to recommend operation when the history of



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ulcer has been of short duration. Perhaps this is based on sound judgment because in such cases the results of gastroenterostomy have not been creditable. Operation in many early cases has disclosed symptomatic ulcer. Nowhere in surgery has the unquestionable evil of an operative procedure been established as in the case of gastroenterostomy for the symptoms of ulcer without a demonstrable lesion. Experimental ulcers develop within six weeks to two months. Perhaps in the human subject this period is longer. In clinical experience it is not uncommon to have symptoms of secondary ulceration develop within two or three months after gastroenterostomy. We have seen many cases of acutely perforated duodenal ulcer with a history of only several weeks' duration. From a pathologic standpoint, and this coincides with clinical facts, a duodenal ulcer of several months' duration carries the same hazardous complications of perforation and hæmorrhage as does an ulcer of years' duration.

The obvious fact in the etiology of ulcer is that the causative agent not only initiates the lesion but is responsible for its chronicity. We believe that the causative agent is excessive gastric acidity which through failure of the mechanism of neutralization exposes the duodenal mucous membrane to the injurious effects of acid. The hindrance to duodenal regurgitation in cases of ulcer is the abnormal action of the pyloric sphincter. The test of the correctness of this theory should be the results in patients with ulcer in whom the activity of the sphincter has been abolished.

The technic of the operation has been previously described. In simple terms it consists of the submucosal removal of the anterior half of the pyloric sphincter. The procedure while necessitating meticulous attention to the details of dissection can be completed in ten minutes. There should be no mortality. The final result does not disturb the normal anatomic relationships. The sphincter is put completely out of commission because one-half of it is removed. Simple cross-section of the sphincter as in the Ramstedt operation in our opinion does not permanently abolish sphincteric action. Plastic operations on the pylorus in which the lumen is deliberately opened eventually may lead to cicatricial stenosis. By removing half of the sphincter without opening the lumen scar tissue is reduced to a minimum, stenosis does not occur and the sphincter is rendered inactive through loss of half its substance and interruption of nerve pathways. In our practice the operation is performed in every case of duodenal ulcer, unless certain conditions make it technically impossible to do so. These conditions have to do with a firmly fixed pyloro-duodenal area which make it inaccessible for the operative manoeuvres. Excessive scar tissue or periulcerous exudate are technical contraindications. In such instances we perform gastroenterostomy. In several cases of acutely perforated duodenal ulcer we have closed the perforation and then removed the anterior half of the sphincter.

*Results.*—In our early experience before perfection of technic we committed such errors as accidental opening into the duodenum and failure to

remove completely all the muscle fibres in the anterior half of the sphincter. These errors have an effect on the post-operative results.

During the years 1928, 1929, and 1930, ninety-one patients with duodenal ulcer were operated on. Forty-four of these were treated by removal of the anterior half of the pyloric sphincter. In addition to the operation for ulcer, in many cases coincident lesions as appendicitis and cholecystitis received operative attention. This report concerns the forty-four patients who had a demonstrable duodenal ulcer and in whom the anterior half of the pyloric sphincter was removed. Four patients died in the hospital; one from respiratory failure three days after operation, one from uræmia ten days after operation, one from cardiac disease thirteen days after operation and one from peritonitis thirteen days after operation. Of the remaining forty patients, thirty-five were seen and examined at regular intervals in the follow-up service of the Lankenau Hospital over a period varying from two months to three and one-half years after operation. The examinations were made by members of the hospital staff. Results of the examination were graded from one to four. A patient who had complete relief of pre-operative symptoms was graded four while one who experienced little or no relief was graded one. On this basis, twenty-six patients were graded four, five were graded three and four graded two. It was noted that the improvement or relief of symptoms did not diminish as the post-operative period lengthened.

Fluoroscopic examination of the stomach after an opaque meal was made in sixteen patients during the course of the observations in the follow-up service. In all patients it was noted that the emptying time was normal or slightly accelerated although in many of these the pre-operative study had shown delayed emptying or actual retention. It was difficult for the röntgenologist to give a definite opinion regarding direct signs of ulcer in the duodenal cap because of the confusion arising from the proximity of the operative site. In all patients except three the indirect signs of ulcer had disappeared. Post-operative gastric analysis by means of the fractional test was carried out in a sufficient number of patients to determine that there was no significant change from the pre-operative findings. We do not attach much importance to these results for the reason that the usual fractional analysis after a test meal gives little positive information regarding duodenal regurgitation and the actual concentration of acid entering the duodenum. Important evidence regarding the efficacy of the operation on the sphincter in restoring duodenal regurgitation could be obtained by means of the acid test meal. This we have not done but propose to do it in future cases. At the present stage we can only say that regardless of laboratory studies the operation has given symptomatic relief.

*Conclusions.*—It seems that duodenal ulcer usually occurs in individuals who have a constitutional hyperacidity. From experimental and clinical studies it seems that acid is the direct causative factor in the initiation and maintenance of duodenal ulcer. That all individuals with temporary or persistent hyperacidity do not develop ulcer is probably due to the safety control mechanism

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of duodenal regurgitation. Studies have shown that patients with ulcer have deficient duodenal regurgitation or are unable to neutralize efficiently acid injected into the stomach. The clinical symptoms of ulcer can be explained on the basis of pylorospasm. Dysfunction of the pyloric sphincter not only causes the symptoms of ulcer but precedes the appearance of ulcer. The combination of dysfunction of the pyloric sphincter and hypersecretion of acid gives rise to duodenal ulcer. The control of the hypersecretion of acid is difficult and uncertain by medical means alone. The other factor, the pyloric sphincter, in the etiology of ulcer can be removed by a surgical procedure. Removal of the anterior half of the pyloric sphincter by the method described permits uninterrupted regurgitation of duodenal contents into the stomach thereby attaining control of acidity. This operation does all that gastroenterostomy can do and all that medical treatment tries to do. It restores nature's method for the control of acidity. It is based on sound physiologic principles. It is generally agreed that when gastric acidity is controlled a duodenal ulcer will heal and that symptoms will disappear when pylorospasm is relieved. The operation on the sphincter accomplishes both objectives. The advantages of the operation are, its simplicity of performance; there is no disturbance of anatomic relationships and there is no opportunity for the development of anastomotic ulcer. In our practice, submucosal removal of the anterior half of the pyloric sphincter is the operation of choice for duodenal ulcer. Certain contraindications are stated. Results are given in forty-four patients with duodenal ulcer in whom the anterior half of the pyloric sphincter was removed.

## HEMANGIOMA OF SIGMOID AND COLON

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HEMANGIOMA of the large bowel is a relatively rare disease. Nevertheless the mortality has been so high and the operative results so unsatisfactory that the report of a case with a satisfactory cure seems justified. In the case to be reported the area of the tumor corresponded to the distribution of the superior hæmorrhoidal vein. Assuming that there would be a free venous communication between the vein and the dilated areas of the tumor, a plan was devised for obliterating the venous sinuses—with resultant cure. The details of the operative procedure, colostomy and later closure of the colostomy are described in the case report in the latter part of this article.

A search of the literature for hæmangiomas of the colon show few reported cases.

The end-results of these cases showed that death occurred from hæmorrhage; or resection or permanent colostomy were performed to relieve the symptomatology. As the disease is usually congenital, the symptoms of bleeding occur in early life, and as a result the normal activities of youth are restricted and the outcome is indeed tragic.

*Pathology.*—If one accepts the theories propounded by Virchow, Ribbert, and Fraser that hæmangiomas are localized encapsulated tumors it is questionable whether one can definitely classify the vascular tumors seen in the large bowel under the terminology of hæmangioma.

Ribbert, working on cavernous angiomas with particular reference to the small telangiectatic tumors of the skin and the cavernomas seen in the liver, states that the tumor, consisting of vessels with thin walls surrounded by a connective tissue stroma containing few cells, has no direct connection with the capillaries of the normal surrounding tissue. There is no interconnection with the surrounding vessels, no indication that the dilated lumina gradually contract to merge with the capillaries or possibly have developed from them. This impression, according to Ribbert, is absolutely not changed by the fact that arterial vessels enter while venous vessels emerge from angioma or that individual sections demonstrate this communication. Ribbert also says that there is no justification for assuming that originally the vessels of the hæmangioma were the normal part of the vascular system and developed later into a tumor. He believes that the vascular complex producing the new growth was an independent entity from the beginning and not a preëxisting dilatation of normal vascular channels. Virchow, Rindfleisch, and Ribbert believe that cavernomas are due to the primary development of connective tissue infiltrating the surrounding tissues gradually without any distinct mi-



croscopic visible formation. The vessels are subsequently formed within this connective tissue. Ribbert injected the vessel walls of angiomas of the skin and of cavernomas of the liver and was able to show that the injected solution was seen exceeding the limits of the tumor only where arterial vessels entered it and venous vessels emerged from it. There was no direct connection between the capillaries of the tumor and the surrounding capillaries of the host.

Fraser states in congenital hæmangiomas these vessels are originally formed in the vascular areas of the mesoderm of the embryo. Certain cells of the mesoderm (angioblasts) become vacuolated, and proliferate in such a way as to form a syncytium. Fluid collects within the vacuoles, which, enlarging and proliferating, give rise to minute reddish specks, the so-called "blood islands of Pander." The enlarged parts of the syncytium are united to one another by narrower parts, and after a time the cavities extend into the narrow portion, so that a network is produced. The walls of these primary vessels are composed at first merely of the protoplasm of the syncytium, with nuclei embedded in it here and there. Subsequently, the protoplasm becomes differentiated around the nuclei into the flattened cells which compose the walls of the capillaries, and which form the lining walls of the arteries and veins. As they are developed, the vessels are backed by a very slight amount of connective tissue which forms a stroma that binds them together. Sometimes the stroma is abundant, so that the tumor appears more or less scirrhous-like in type.

*The Further Evolution of the Tumor.\**—There are at least four possible and different directions in which the evolution of the tumor may occur: (1) Its growth may become arrested, the tumor eventually undergoing spontaneous cure by a process of fibrosis; (2) the tumor, while retaining the characteristics of a capillary hæmangioma, continues to grow by a process of infiltration of the surrounding parts; (3) the original capillary type of hæmangioma becomes converted into a cavernous type of hæmangioma; (4) the original capillary type of tumor becomes converted into what we have termed the compact type of hæmangioma.

1.—*Natural Arrest and Spontaneous Cure.*—The connective-tissue stroma which, in greater or lesser quantity, always surrounds the tumor elements, is converted into a dense fibrous tissue. By a perivascular and endovascular thickening; the blood-vessels undergo a progressive obliteration. The diminished blood-supply, and the pressure of the surrounding fibrous tissue, eventually lead to a complete disappearance of the tumor tissue, its position being replaced by fibrous tissue.

2.—*Progressive Spread and Infiltration.*—Infiltration is extensive in the subcutaneous fatty tissue, the tumor extending between individual fat cells, and among the fibres of the connective-tissue stroma. The deeper the examination is carried, the less marked does the infiltration become. To some

\* Fraser, John: Hæmangioma Group of Endothelialioblastomata. British Journal of Surgery, vol. vii, p. 335, 1929-1930.

extent infiltration occurs in muscle, the tumor extending between individual muscle fibres. Where nerves are present the sheath of the nerve is invaded, and there is a spread inwards between individual nerve fibres.

3.—*The Development of the Cavernous Type of Hæmangioma.*—If the embryonic capillary tissue develops a connection with the circulation, the cavernous type of hæmangioma may result. The original embryonic capillary vessels become distended, probably from the passage through them of the circulating blood under some degree of pressure. The lining endothelium becomes very much thinner, and the cavity is filled with blood, which, judging from the character of its corpuscular elements, is in active circulation. In this last respect the contents of the cavernous hæmangioma differs very markedly from that of the capillary type, the corpuscular contents of which are either imperfectly developed or degenerated. It is the exception to find a tumor in which the cavernous change has become general; in almost every instance, if the cavernous tumor is present, it is associated with the capillary type, and with varying changes in transition between the two.

4.—*The Development of the Compact Type of Hæmangioma.*—If, for some reason, the endothelial cells lining the capillary type of tumor take on active proliferation, the compact type of hæmangioma may develop. Generally the proliferation is perivascular in type; occasionally it is endovascular, the cells projecting in papilla-like arrangement, and becoming arranged in concentric masses and whorls. The development of the compact variety of hæmangioma is accompanied by a localization of the tumor.

In our case, where no specimen was removed for examination, it is difficult to state whether or not the diffuse cavernous dilatation of the vessels was in truth a tumor growth or a dilatation of existing vessels. As can be seen in the illustration there was no sharp demarcating line between the angioma and the normal bowel. Throughout the area of about an inch and a half there was a gradual transition from dilated to normal vessels. Also it was obvious that there was a free, open communication between the superior hæmorrhoidal vein and the dilated vessels within the lumen and on the surface of the affected colon.

*Symptoms.*—As can be seen in Chart I the most prominent symptom in the cases reported is repeated bleeding from the rectum, often beginning in infancy. As a result, a true anæmia occurs, frequently associated with asthenia and cachexia. The hæmorrhages may be small, or sufficiently massive to cause exodus. In a number of cases hæmorrhoidectomy has been performed without satisfactory cure. In one case intestinal obstruction was created by a pedunculated submucous angioma.

#### SUMMARY OF REPORTED CASES

CASE I.—Reported by Barker, 1883, male, forty-five years of age. Symptoms.—Diarrhœa with hæmorrhage; occasional constipation. Duration.—“Since boyhood.” Treatment.—Injections of Tr. Fer. Perchlor. Rest in bed. Results.—Death. Nævoid growth in lower rectum.

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CASE II.—Reported by Marsh, 1883, female, ten years of age. Symptoms.—Repeated hæmorrhage from bowel. Duration.—Since age of two. Treatment.—Cauterization. Results.—Relieved symptoms but did not cure growth.

CASE III.—Reported by Benneke, 1906, male, fifty-two years of age. Symptoms.—Not stated. Died of tubercular meningitis. Duration.—Not stated. Results.—Post-mortem examination hæmangioma of entire intestine.

CASE IV.—Reported by Tuffier, 1913, male, thirty-one years of age. Symptoms.—Intestinal hæmorrhage and anæmia. Duration.—Seven years. Treatment.—Cauterization; later operation. Results.—Death after laparotomy.

CASE V.—Reported by Hartmann, 1913, female, twenty-two years of age. Symptoms.—Rectal hæmorrhage. Duration.—Not stated. Treatment.—Cauterization. Results.—Recovery.

CASE VI.—Reported by Kausch, 1914, male, seventeen years of age. Symptoms.—Blood in stool; hæmorrhage and anæmia. Duration.—Since first year. Treatment.—Operated in fourth year for congenital hæmorrhoids. Hosp. tr. 1911-1912, artificial anus; removal of polyp from anus. 1913-1914, five-stage operation. Results.—1916, general condition greatly improved.

CASE VII.—Reported by Dujarier and Topous Khan, 1920, male. Symptoms.—Intermittent rectal hæmorrhage; anæmia; loss of flesh. Duration.—Three years. Treatment.—Exploratory laparotomy. Results.—Not stated.

CASE VIII.—Reported by Hennig and Schütt, 1923, male, twenty-three years of age. Symptoms.—Rectal hæmorrhage; blood in stool. Duration.—Since age of seven. Treatment.—Operation for lymphangioma of knee. Rectal examination not made. Results.—Post-operative rectal hæmorrhage. Impossible to operate. Death.

CASE IX.—Reported by Reichel and Staemmer, 1924, male, seventy-eight years of age. Results.—Seen at autopsy.

CASE X.—Reported by Buie and Swan, 1929, female. Symptoms.—Symptoms of gall-bladder disease. Duration.—Not stated. Treatment.—Gall-bladder operation. Examination of appendix. Results.—Diffuse venous hæmangioma of appendix and cæcum.

CASE XI.—Reported by Buie and Swan, 1929, female, forty-eight years of age. Symptoms.—Passage of small amounts of blood. Duration.—Four months. Acute obstruction one month. Treatment.—Operation for obstruction. Results.—Annular cavernous hæmangioma in colon.

CASE XII.—Reported by Hume, Graydon O., 1922, male, forty-eight years of age. Symptoms.—Repeated rectal hæmorrhages. Duration.—Since age of twelve. Treatment.—Transfusion and packing of rectum with kaolin paste. Results.—Death by hæmorrhage.

CASE XIII.—Reported by Bensaude and Antoine, 1923, female, twenty-one years of age. Symptoms.—Hæmorrhage of the rectum associated with pain, anæmia, severe cachexia. Duration.—Many years. Treatment.—Operation: Diffuse angioma of rectum and sigmoid. Artificial anus made in transverse colon. Post-operative X-ray therapy. Results.—Improved. (Still under treatment.)

CASE XIV.—Reported by Bensaude and Antoine. Symptoms.—Profuse hæmorrhages of rectum. Duration.—Not given. Treatment.—Operation. Symptomatic and injections morphine. Results.—Death from hæmorrhage.

*Treatment.*—In the cases noted palliative measures, such as irrigations of styptic substances per rectum, rest, morphine, transfusions, *etc.*, have been the medical therapy. In one case a permanent anus was established and the bowel containing the angioma resected. In another a permanent colostomy was made in the transverse colon, and the sigmoid treated by radium therapy.

*Diagnosis.*—In any patient who complains of persistent bleeding from the rectum over a period of years, usually beginning in infancy, angioma should

be suspected. If the angioma occupies the rectosigmoid, the diagnosis may be readily made from the appearance as seen by proctoscopic examination. Unless there should happen to be a pedunculated tumor X-ray is of little importance from a diagnostic point of view.

**CASE REPORT.**—B. L., male, Russian Jew, born in the United States, aged seventeen. First admission to Fifth Avenue Hospital March 12, 1930. *Chief complaint.*—Bleeding from rectum. Since fifteen months of age patient has complained of frequent attacks of bleeding from the rectum. He has had no pain except when passing a constipated stool. Has periods of diarrhoea and constipation, and stools always appear streaked with very dark blood. At times when he has diarrhoea he passes bright red blood, which varies in amount from a quarter to a half glass at a time. There are times when he uses mineral oil, when he has very little bleeding. These times he may bleed only once out of about ten times.

*Past History.*—Diphtheria as a child. At four years of age had an operation for hæmorrhoids; and other rectal operation, of which he is not quite certain, at about six years of age. Becomes short of breath on exertion, and has had fainting sensations and has fainted occasionally after any muscular exercise. His best weight has been 142 pounds; at present he weighs 136. Has never been able to exercise on account of faintness.

*Physical Examination.*—Pale, slender youth. Eyes react to light and accommodation. Pupils are equal. Mouth in good condition. Tonsils absent. Lungs clear throughout. Heart: Regular rhythm, fair quality. Has a powerful beat with P. M. I. within mid-clavicular line in fifth interspace. No irregularity or murmurs. Abdomen negative. Some gas in intestines noted.

*Digital Examination.*—There is no enlargement of the prostate, or noticeable hæmorrhoids. There seem to be a few tabs of mucosa just within the sphincter.

*Laboratory Examination.*—*Urine.*—Specific Gravity, 1020. Very faint trace of albumin. Microscopic negative. *Blood Count.*—Hæmoglobin, 32 per cent; Red Blood Cells, 2,800,000; White Blood Cells, 6,500; Polynuclears, 77 per cent; Lymphocytes, 23; Achromia; Aniscytosis; Poikilocytosis. *Blood Clotting Factors.*—Prothrombin, 1.0; Fibrinogen, 0.64; Antithrombin, 1.0; Platelets, 370,000; Disintegration, 40 per cent; Index, 0.6.

*Proctoscopic Examination,* March 12, 1930.—Sigmoidoscope admitted without meeting any obstruction for ten inches. Examination reveals a red, beefy mucous membrane, with areas of blue cystic spaces beneath, and thin, smooth mucous membrane extending upward as far as can be seen through the sigmoidoscope and downward to the sphincter ani. There are two small hæmorrhoids just within the sphincter.

*Diagnosis.*—Congenital angioma of the rectum.

A similar proctoscopic examination had been made two weeks before admission, and the patient referred to Dr. Harvey Stone, in Baltimore, with a request for his opinion, without the author having stated his own diagnosis.

Following is the report from Doctor Stone: "The boy has two distinct lesions which may, or may not, be related to each other. There is a fairly large and vascular internal hæmorrhoid just to the left of the posterior commissure, and a smaller one further to the left of this. In addition to that, the rectal mucous membrane from just above the valves to ten inches up (which was as far as I could see) presents a curious condition. The veins are greatly dilated and engorged and tortuous. They stand out like blood splotches against the pale mucous membrane. I think this is a congenital angioma.

*Comment.*—A boy of seventeen years of age presented himself for treatment, having had repeated bleeding from his rectum since fifteen months of age. He had a marked secondary anæmia and suffered from repeated bleed-



ing at stools. A diagnosis of angioma was made by proctoscopic examination and by the history. The problems which presented themselves when operation was contemplated were: (1) Would one be able to see, on the serosa side of the intestine, the distribution of the angioma? (2) If the growth were limited, obviously colostomy would relieve the situation temporarily, but should the fecal current be reestablished, bleeding would probably then recur. (3) A permanent colostomy, with or without resection of the entire distal sigmoid, was considerably of a handicap. For a boy of seventeen to feel that the rest of his days he would have to wear a colostomy cup or bandage did not present a pleasant future. (4) Having learned that certain port wine hæmangiomas had been cured by the injection of the veins with sclerosing substances, the author considered the use of this method in this particular case. Obviously, arterial injection might create gangrene of the bowel. If there were a free communication, as the pathology would suggest, between the superior hæmorrhoidal vein and the numerous venous sinuses, a sclerosing solution such as is used in the treatment of varicose veins of the extremities might readily eradicate the tumor. The possibility of gangrene of the bowel, following this injection with the necessity of a hurried second-stage abdomino-perineal excision of the rectosigmoid, was considered, but the seriousness of the boy's condition seemed to warrant this possible risk. At the time this operation was contemplated, the later sclerosing solutions such as invertose, quinine and urea, and sodium chloride, had not come widely into use. It was felt, with the possibility of only one injection, that a strong solution of sodium salicylate would be warranted. For this reason, 40 per cent. sodium salicylate was the substance selected for the intravenous injection.

As the boy had two small hæmorrhoids, these were removed as a preliminary operation, in association with a couple of transfusions, in preparation for the major operation.

It was thought, in planning the operation, that a temporary colostomy would be necessary to put the bowel at rest, in addition to the intravenous injection of the sclerosing solution.

B. L. (First operation) April 10, 1930. (1)—Colostomy. (2)—Ligation of Superior Hæmorrhoidal Vein. (3)—Injection of Superior Hæmorrhoidal Vein with sclerosing solution (10 cubic centimetres of 40 per cent sodium salicylate). A right paramedian incision was made. On exposing the peritoneum the sigmoid and rectosigmoid were purple in color with distended tortuous vessels over the entire surface up to about 10 centimetres of the end of the descending colon. (See artist's sketch.)

The line of demarcation between normal and abnormal bowel was distributed over an area of about 2 inches, where vessels decreased in size until a normal appearance occurred. This occurred about 4 inches distal to junction of descending colon and sigmoid. Adhesions to lateral surface of sigmoid were freed so that it was possible to bring up the sigmoid for a colostomy. The mesosigmoid was perforated in the avascular zone and tape inserted through it. The portion of the bowel containing the angioma was then brought up into the wound and the mesosigmoid perforated on the mesial surface. It was seen that the part involved was apparently in the distribution of the superior hæmorrhoidal vein. The walls of the vein were extremely thin and there was an aneurysmal dilatation at the area exposed. The vein was dissected free from artery by sharp dissection and



ligature placed about it and tied. A needle attached to a hypodermic syringe was inserted into the lumen of vein distal to ligature and 10 cubic centimetres of 40 per cent. sodium salicylate injected, very little spilling. It appeared to the operator and his assistant that shortly after this the purplish color of the intestines became lighter—almost pink. Ves-



FIG. 1.—Artist's sketch made at operation. Exposure of superior hemorrhoidal vein through mesial sheath of meso-sigmoid. Upper portion shows gradual transition of the tumor into normal bowel.

sels felt firm. The vein was again ligated below insertion of needle and the peritoneal cavity washed out with saline. The rent in the mesosigmoid was closed with chromic suture. A left McBurney incision was then made, incising skin and inserting Kelley clamp and spreading it so as not to split aponeurosis of oblique muscles any more than was necessary. Tape about the sigmoid was drawn up through this incision and the

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bowel brought up through the skin incision. On the peritoneal side the bowel was united to the peritoneum with interrupted chromic sutures and lateral surface of the descending colon sutured to the lateral surface of the peritoneum to prevent bowel from herniating in this zone. Vaseline gauze tape was placed through the mesentery in place of tape that had been there previously. The bowel was sutured on the outside of the aponeurosis of the external oblique with interrupted fine chromic. Vaseline gauze inserted around colostomy. Median abdominal wound closed in the routine manner.

Colostomy opened by cautery at end of forty-eight hours. Rectal tube inserted and held by purse-string sutures.

Four days later colostomy revised with endotherm knife.

*Post-operative course.*—Patient ran a smooth post-operative course, the colostomy worked satisfactorily, and he left the hospital at the end of three weeks.

Eight weeks after operation he was proctoscoped: At that time the dilated venous pools had completely disappeared. There were one or two areas of necrosis of the mucous membrane, with some sloughing. There had been no bleeding from the rectum since his operation. He was instructed to irrigate the distal segment of his colostomy with warm cotton-seed oil twice a week.

Seven months post-operatively the patient had gained 20 pounds and, for the first time in his life, had been able to enter into active sports; he had no difficulty in the use of his colostomy; and he had had no bleeding from the rectum.

As he was anxious to make up his classes in which he had become deficient due to his prolonged invalidism, we postponed the return to the hospital for closure of his colostomy until eleven months following the initial operation.

Three weeks before his re-admission, March 10, 1931, he was again proctoscoped. At this time the mucous membrane appeared somewhat atrophied. There were whitish scar-appearing specks where previously there had been dilated submucous venous spaces. It was explained to his parents that it would be necessary to explore him through his old median incision before deciding whether or not his colostomy could be closed. It was felt that the inspection of the colon where previously there had been tremendously dilated veins appearing on the subserosal surface of the sigmoid would indicate whether or not the sclerosing solution had obliterated them sufficiently to attempt a reestablishment of the faecal current. It was also explained to the boy's parents that a cæcostomy would be necessary in order to allow satisfactory closure of his colostomy after this long period of disuse.

(Second Operation) March 30, 1931. (1)—Exploratory laparotomy. (2)—Closure of colostomy. (3)—Cæcostomy. (4)—Appendectomy for chronic appendicitis. Ethylene anaesthesia. (1) Elliptical median incision excising the old scar, after having excluded the cæcostomy from the operative field by a gauze pack and placing over it a folded towel. The sigmoid was sought for and brought up into the wound. The appearance was entirely different than at the previous operation. The sigmoid had atrophied from disuse and the appearance of the vessels on its surface had changed noticeably. While there were still a few dilated veins the greater number appeared thrombosed and it seemed as if the vessels on the surface had diminished greatly in number. While the appearance of the serosa had previously been a deep purple it now had the normal pink appearance of intestines. It appeared to the majority of those present in the operating room as if it were safe to reestablish the faecal current. Therefore sterile string pads were placed over the median incision, the towels were refixed and (2) an elliptical incision was made about the former colostomy after excising the skin and skin was sutured over the colostomy opening to prevent soiling. By sharp dissection the intestine was freed from the layers of the left McBurney incision. When the sigmoid was freed the scar tissue was excised from the edges of the colostomy and the opening was closed in a transverse manner with an interior Pagenstecher inverting a suture reinforced with a continuous chromic mattress stitch. The sigmoid was then replaced in the abdominal cavity and the median incision was again exposed.

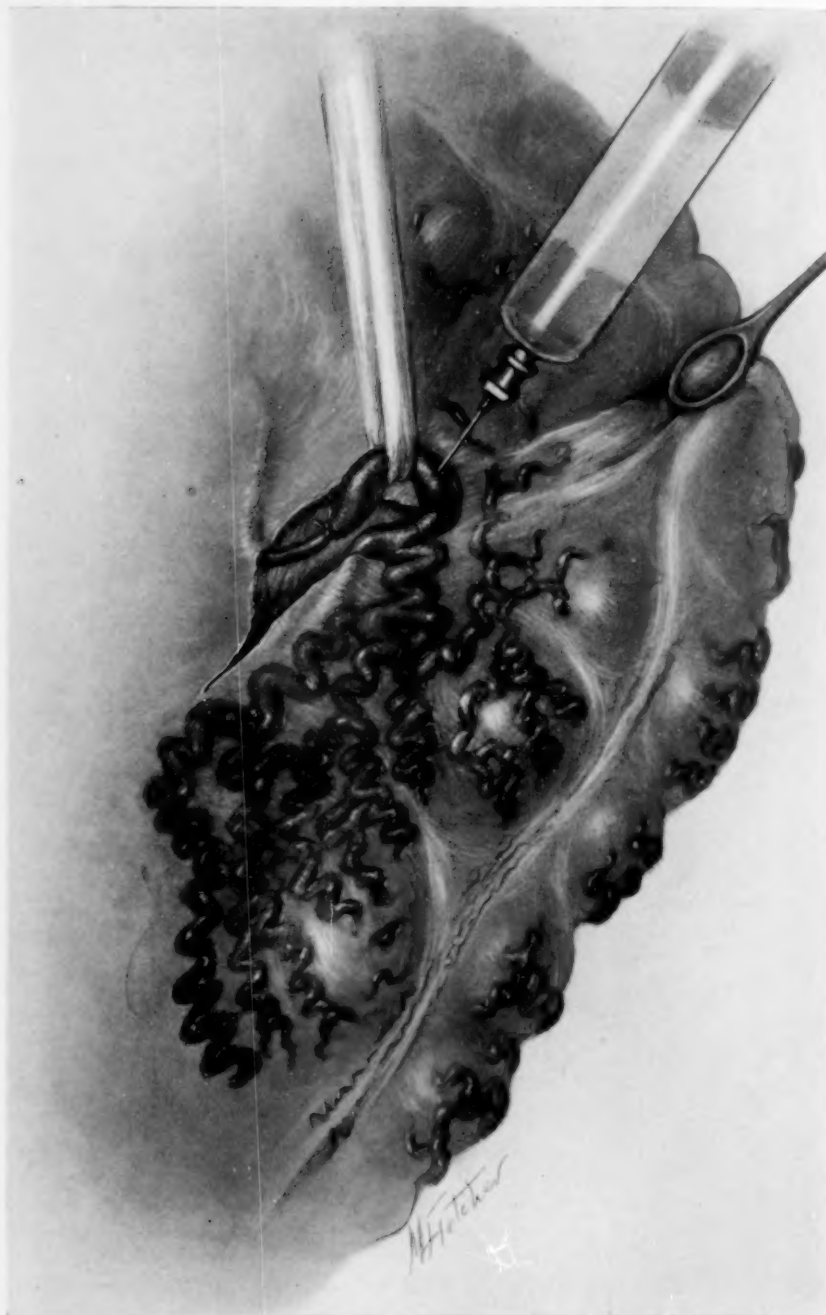


FIG. 2.—Artist's sketch taken at operation. Injection of the superior hæmorrhoidal vein with sclerosing solution.

## HÆMANGIOMA OF SIGMOID AND COLON

(3 and 4) The cæcum was then sought for and an elongated appendix found with adhesions in the middle third, binding it laterally, and sharply kinked. The appendix was removed with a double inversion of the stump. About 8 centimetres distal to the ileocæcal junction a purse string suture was inserted. A stab wound was made and a large rectal tube inserted and passed up to the ascending colon. The tube was held in place by three reinforcing additional purse-string sutures. A small right McBurney incision was made and the distal end of the tube drawn out through this incision and the cæcum sutured to the peritoneum at its exit. The median and the left intermuscular incision were then closed.

*Post-operative Course.*—On the twelfth post-operative day the patient developed a faecal fistula in the median incision, which created a small breaking down of the incision for a distance of about 3 centimetres. The cæcostomy tube had been removed on the eighth post-operative day. The patient was discharged from the hospital on his twenty-sixth post-operative day, at which time all three wounds were healed with the exception of a very slight seepage through the median wound, which was not faecal in character. The patient had no bleeding from his rectum and his bowels moved regularly each day with the aid of mineral oil. His general condition was satisfactory.

A follow-up report from the patient on July 1, three months after his operation, stated that the boy was away at camp, was feeling perfectly well, and his bowels moved daily with the aid of a small amount of mineral oil. Twice in the first fortnight after he returned home, when his bowels were very constipated, he had a slight amount of blood-tinged mucus coating a hard stool. Since then he has noticed no blood whatsoever, is able to exercise, and to act as other youths of his own age.

As fifteen months have elapsed since the injection of the sclerosing solution into the superior hæmorrhoidal vein and no bleeding has occurred during that time, the assumption that the patient is cured appears warranted.

*Conclusions.*—(1) Hæmangioma of the rectosigmoid is usually congenital in origin. (2) The most prominent symptom is repeated bleeding from the rectum, usually beginning in the first decade of life. (3) The condition is serious, as death from hæmorrhage is apt to occur. The treatment of the cases reported has been, in general, unsatisfactory. (4) A case is reported wherein a cure was accomplished by the injection of the superior hæmorrhoidal vein with a sclerosing solution. Colostomy and later closure of the colostomy was performed in order to put the bowel at rest during the period of repair.

### REFERENCES

- Barker, E. T.: Cavernous Nævus of Rectum Proving Fatal in an Adult from Hæmorrhage. *Med.-Chir. Tr. Lond.*, vol. lxvi, pp. 229-233, 1883.
- Benneke, H.: Ueber kavernöse Phlebektasien des Verdauungstraktes. *Virchow's Arch. f. path. Anat.*, vol. clxxxiv, pp. 171-176, 1906. Case. Nodules found in entire intestinal tract from duodenum to rectum.
- Brown, A. J.: Vascular Tumors of the Intestine. *Surg. Gynec. and Obst.*, vol. xxxix, pp. 191-199, 1924. His case was in small intestine, but he gives tabular summary of previously reported cases, and references.
- Buie, L. A., and Swan, T.: Benign Tumors of the Colon. *Surg. Clin. North America*, vol. ix, pp. 893-910, 1929. Fifty-two cases from Mayo Clinic. Two cases of hæmangioma, pp. 903-904.
- Dujarier, C., and Topous Khan, E.: Varices do méso-sigmoïde avec angiomes caverneux multiples de l'S iliaque. *Bull. et mém. Soc. anat. de Par.*, vol. xc, pp. 33-34, 1920.

FREDERIC W. BANCROFT

- Helverstine, F., Jr.: Hæmangioma of the Intestine. *ANNALS OF SURGERY*, vol. lxxviii, pp. 42-47, 1923. His own case in small intestine, but summarizes Tuffier's, Hartman's, and Dujarier's cases (q.v.).
- Hartman: (Case) *Bull. et mém. Soc. de chir. de Par. n. s.*, vol. xxxix, p. 284, 1913.
- Hennig, and Schütt: Ein Fall von diffusem, kavernösem Hämangion des Mastdarms. *Mitt. a. d. Grenz. d. Med. u. Chir.*, vol. xxxvi, pp. 235-242, 1923. Cites earlier cases.
- Kausch, W.: Ueber Varicose und Cavernöse des Mastdarms, *Verhandl. d. deutsch. Gesellsch. f. Chir.*, vol. xliii, Pt. I, pp. 243-245, 1914; Ein kavernöses Angiom des ganzen Mastdarms (Mastdarm-exstirpation in fünf Zeiten). *Mitt. a. d. Grenz. d. Med. u. Chir.*, vol. xxix, pp. 399-423, 1916-17. Says he has only found one similar case in the literature—that of Barker (q.v.).
- Marsh, H.: (Case) *Lancet*, vol. i, p. 637, 1883. Reported during discussion of Barker's case.
- Reichel, P., and Staemmler, M.: Die Neubildungen des Darmes. Stuttgart, Enke, 1924. (Neue deutsche Chir. 33a). Hæmangioma, pp. 282-284. Bibliography, p. 372.
- Tuffier: Angiomes de l'intestin; angiome de l'S iliaque avec hémorragie profuse. *Bull. et mém. Soc. de chir. de Par. n. s.*, vol. xxxix, pp. 268-275, 1913.
- Bensaude, Raoul, and Antoine, Edouard: Diffuse Cavernous Angioma of the Rectum. *Archives des maladies de l'appareil digestif*, vol. xiii, p. 1, January, 1923.
- Fraser, John: Hæmangioma Group of Endothelioblastomata. *Brit. Journal of Surg.*, vol. vii, p. 335, 1919-1920.
- Hume, Graydon O.: Hæmangioma of the Rectum. *Guy's Hospital Gazette*, vol. xxxvi, p. 360, September 2, 1922.
- Lynch, J. M., and Felsen, J.: Tumors of the Colon and Rectum, New York, 1925.
- Rankin, Fred W.: Surgery of the Colon. D. Appleton and Co., 1926.
- Ribbert: The Structure, Growth and Origin of Angiomas with Notes on Cystic Development (Ueber Bau, Wachsthum and Genese der Angioma nebst Bemerkungen über Cystenbildung). *Arch. f. path. Anat. u. Physiol.*, vol. cli, pp. 381-401, 1898.
- Rindfleisch: Text-book on Pathologic Tissues, p. 504.
- Virchow: Pathologic Tumors, vol. iii, p. 394.



## SOME ANGIOSPASTIC SYNDROMES IN THE EXTREMITIES

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THE increased interest in the peripheral vascular diseases has focused attention especially on the lesions associated with spasm of the vessels. This is a natural reaction because it is in this group that therapeutic relief can be looked for more hopefully in a large proportion. The group dependent mainly on occlusion of the vessels offers much less opportunity for striking improvement although palliation and slowing of the natural progress of the disease may be brought about.

In previous communications,<sup>1, 2, 3, 4, 5, 6</sup> we have recorded some of our experiences with the more common types of peripheral vascular diseases. But since our interest has been attracted to this subject we have recognized a variety of angiospasm, not dependent on organic vascular disease, which have been difficult to classify under any of the accepted nomenclatures. Indeed, it has been almost impossible at times to be certain even about Raynaud's disease according to the criteria given in the literature for a diagnosis of this condition. We have adopted a tentative classification of our own under which we have placed individual cases of angiospasm in the extremities as they seemed most closely to fit the picture. Thus, in addition to the spastic element in the organic vascular diseases, we have first, idiopathic paroxysmal acral ischaemia generally spoken of as Raynaud's disease; secondly, arteriospasm dependent on organic or functional nervous disorders; thirdly, that consecutive to trauma; and lastly, true venous spasm.

*Vasoconstrictor Gradient in the Hands.*—In former reports we called attention to the normally acting vasoconstrictor gradient which is most marked in the lower extremities after exposure to the air. This gradient also does occur in the hands but it is much less prominent under ordinary conditions. It can be brought out in the hands by fulfilling appropriate conditions as we have already recorded. There is a group of people who normally have an accentuation of vasoconstriction in the hands. They seldom consult a physician as their complaint is regarded by them as trivial, not requiring medical attention. Their only inconvenience is coldness of the hands which may be quite striking in contrast to the warmer portions of the skin surface. The following case history furnishes a well-marked example of this exaggerated vasoconstrictor gradient in the hands.

CASE I.—A. S., Strong Memorial Hospital, No. 38082, a twenty-five-year-old housewife, came into the hospital on account of abdominal pain, due to a chronic salpingitis. In the past history given to the clinical clerk, she said that her hands had always had a marked tendency to be cold. If either hand touched any other part of her body, she felt this difference in temperature. She had never noted any attacks of unusual pallor or cyanosis

in the hands, however. On palpation the hands felt cold and on measurement of the surface temperatures a very sharp vasoconstrictor gradient in the hands was evident. The palmar surface of the fingers registered a temperature of  $22^{\circ}$  when the room temperature was  $19.4^{\circ}$  C. The surface temperature at the wrist was  $28.5^{\circ}$  C. and in the lower arm was  $29.5^{\circ}$  C. This patient had never had any symptoms aside from coldness of her hands which she herself had noted.

This is a much greater degree of vasoconstriction than most individuals will show in the fingers under ordinary conditions with a room temperature of  $19-20^{\circ}$  C. It is difficult to get evidence of spasmodic attacks in these people, many of whom give a story of cold hands and cold feet most of the time. It may be that this is a mild type of reaction which in its more severe forms presents the angiospastic attacks which we call Raynaud's disease. But it seems hardly legitimate to classify this as Raynaud's disease although the difference may be only in degree.

*Idiopathic Paroxysmal Arteriospasm (Raynaud's disease).*—There have been a number of patients with paroxysmal arterial spasms not due to some other disease or injury. Such attacks usually come on in cold weather, but sometimes also during the warmer parts of the year. These patients are completely relieved between attacks at which time upon examination they seem to have normal blood-vessels. The areas involved usually are symmetrical ones on the hands, the feet, or both. The degree of involvement ranges from a mild one with transient dead fingers or toes to a severe one in which attacks of ischæmia are frequent and prolonged, ultimately ending in gangrene of one or more digits. It is possible to bring on typical attacks by exposure of the extremities to a proper degree of coldness; or by allowing rapid evaporation of moisture from the exposed extremities. The attacks are often accentuated by reflex, painful, or psychic stimuli; or may be started by such stimuli when the environmental conditions are suitable. The following three case histories bring out certain points which we wish to emphasize.

CASE II.—E. D. J., Strong Memorial Hospital, No. 45225, a forty-six-year-old housewife, had been having attacks in which several fingers became white, cold and numb during the past eighteen months. The fingers involved remained cadaveric or deeply cyanotic for one-half hour or more at a time and then the circulation gradually returned to these areas accompanied by a tingling sensation. There was no pain during the attacks but the involved fingers were hypersensitive immediately afterwards; on two occasions there has been aching in the arm. Also the attacks were much more apt to occur in cold weather or when she got her hands in cold water, though the low temperature was by no means the only factor in initiating them. The patient had noted herself that the attacks were more numerous when she was nervous; and they frequently occurred upon awaking in the morning. There had been no trophic changes but she was not able to carry out as well-skilled movements with the fingers such as in the use of a needle unless she had warmed her hands in warm water first. Her feet suffered similar changes but the attacks here were less noticeable to her.

Pulsation in all major vessels in the extremities was good even during the attacks. A number of attacks were seen in the clinic involving especially the right index and middle fingers and the thumb. Such attacks were induced by immersion of the hands in cold water of the proper temperature. However, they were not uniformly reproduced

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by the same physical conditions, for immersion in water at  $15^{\circ}$  C. for five minutes one time brought out a sharp attack involving the right index and middle fingers; but on another occasion it failed to do so. Psychic stimuli, such as an unexpected movement of the patient to an examining room, discussion of an operation for an independent condition which the patient had, namely, an epithelioma, *etc.*, produced typical attacks of pallor in certain fingers. However, the attacks induced in this manner at ordinary room temperatures did not usually last as long as those artificially brought on by cold. Recovery from all of the attacks took place spontaneously at a room temperature of

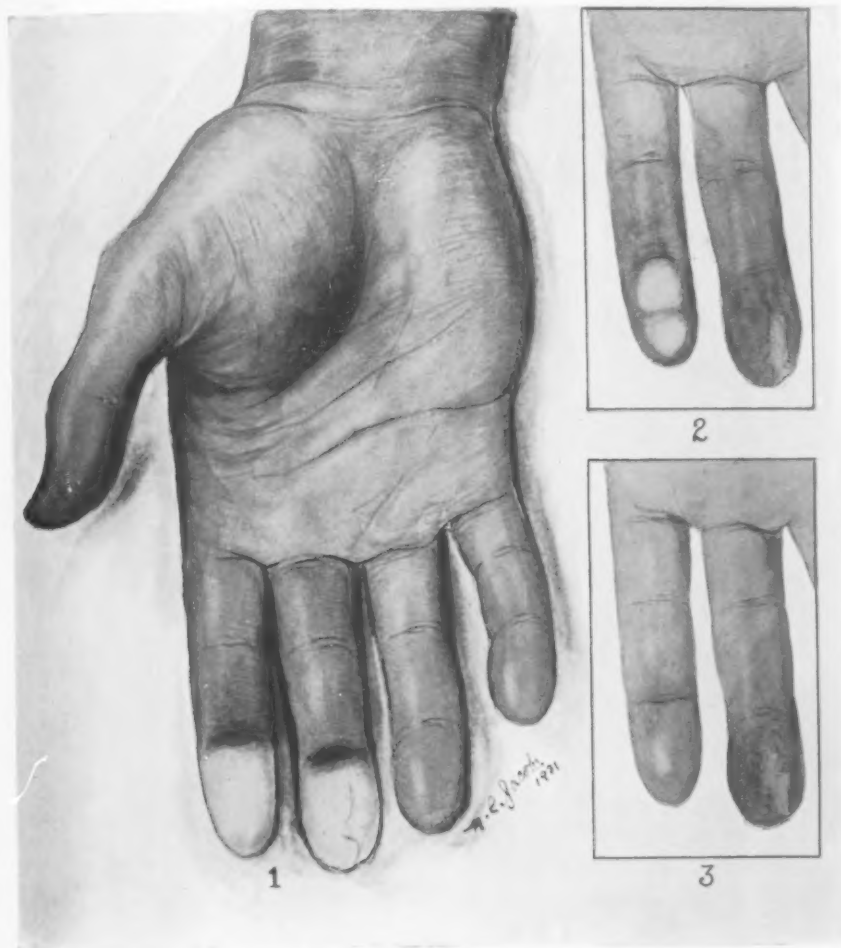


FIG. 1.—Case II. Raynaud's disease, spontaneous recovery. (1) Shows the appearance of the right hand after ten minutes in a water bath at  $15^{\circ}$  C. (2) The white area of the middle finger has become deeply cyanotic and a bar of color has come across the ischemic area in the index finger. This bar gradually became brighter in color and spread throughout the terminal phalanx so that (3) fifteen minutes after coming out of the bath the index finger was hyperemic, while the middle finger was still intensely cyanotic.

$18-20^{\circ}$  C. generally within one-half to one hour. The feet were usually rather cyanotic on exposure for twenty minutes at  $20^{\circ}$  C. The toes showed pallor and fairly intense cyanosis at times, but the condition was not nearly as striking as in the fingers. Spontaneous recovery from an attack in one finger, the distal half of which was dead white, occurred in a somewhat patchy manner, a bar of color coming across the center of the terminal digit while both proximal and distal to that point the finger was still absolutely

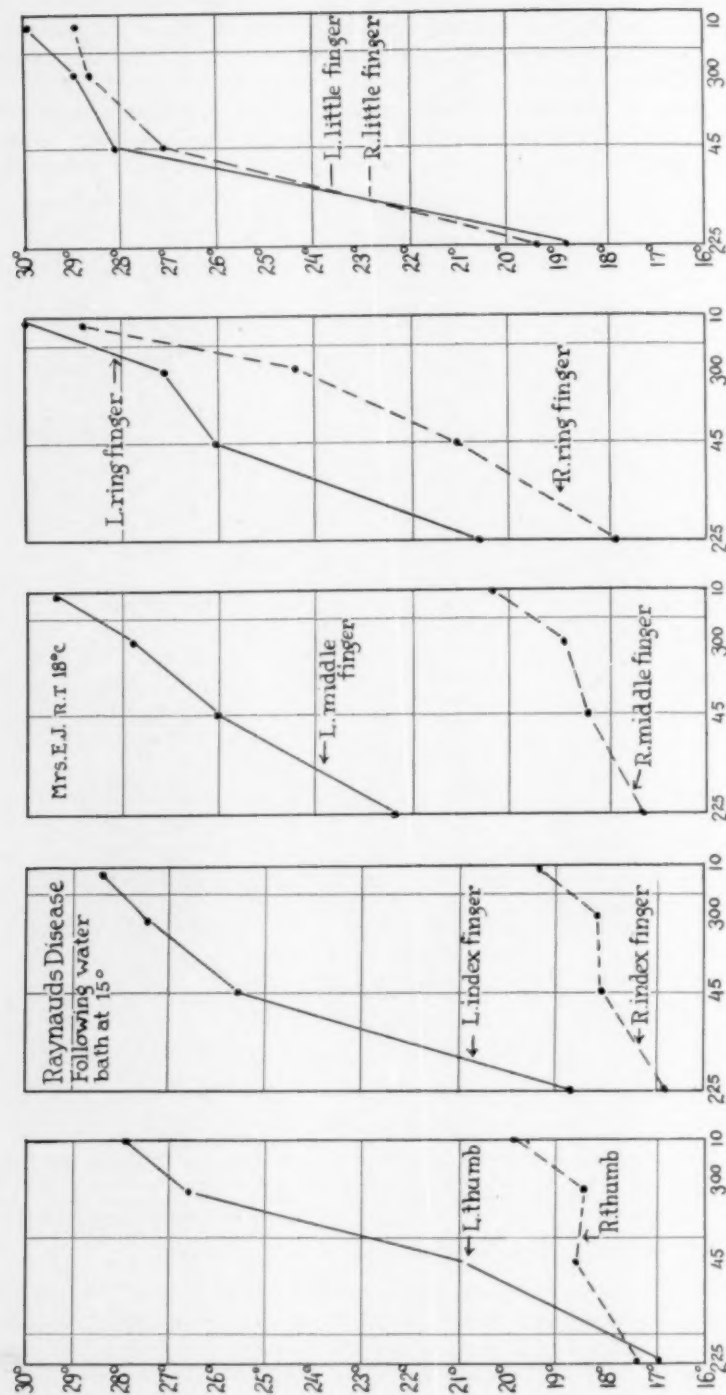


FIG. 2.—Case 11. Raynaud's disease. Surface temperature of the fingers after immersion for ten minutes in water bath at 15° C. Note that the right thumb, index and middle fingers, which were the ones chiefly involved in this case, recovered their temperatures very much more slowly than the corresponding ones on the left hand and the ring and little fingers on both hands.

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ischaemic. (Figs. 1 and 2.) Ten minutes later this finger had not only recovered but was hyperaemic while the middle finger was still intensely cyanotic. An observation of some significance in regard to the influence of nervous stimuli in this condition was the following: The patient had been in the constant temperature room for about two hours. A typical attack of spasm in two of the fingers of the right hand had been induced by immersion in cold water in the early part of this time. The patient had fully recovered from this; both the color of the fingers and their surface temperatures had not changed significantly for an hour. A perineural infiltration was made about the left posterior tibial nerve and the point of the needle touched the nerve trunk causing an instantaneous painful sensation. This produced a sharp attack of ischaemia on the pad of the right thumb (Fig. 3) together with an increase in the rather slight degree of cyanosis already present in the index and middle fingers of this hand. This spastic reaction in the hand lasted for about five minutes. Nerve block of the left posterior tibial nerve caused a temperature rise to the normal vasodilatation level in the anaesthetic area.

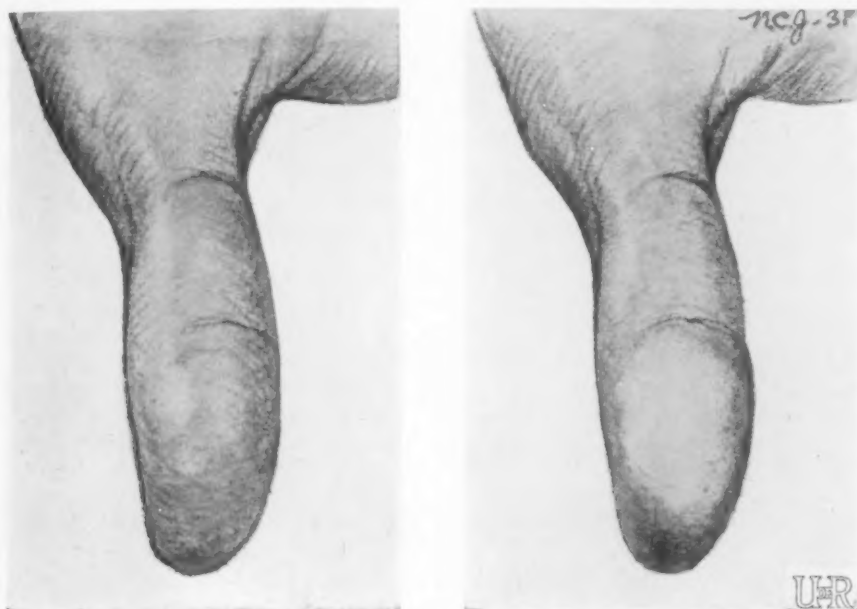


FIG. 3.—Case II. Raynaud's disease. Effect of reflex painful stimulation. (A) Normal appearance of thumb before injection. (B) Ischaemic area on pad of the right thumb which was induced by painful stimulation of the left posterior tibial nerve.

This patient would be regarded as a mild form of Raynaud's disease by some. The beginning of attacks at such a late period in life would be regarded by others as against this diagnosis and they would name it intermittent "dead fingers." It is certain, however, that the conditions necessary for bringing on an attack by exposure to cold had to be strictly followed in her case. An assistant was instructed to put the patient's hands in a water bath at  $15^{\circ}$  C. but being anxious to help, made the temperature  $10^{\circ}$  C. instead. This failed signally to bring on a spasm, the fingers reacting fully with hyperaemia and increased surface temperatures after being withdrawn from the bath, much the same as in normal individuals. Typical attacks could be induced at  $15^{\circ}$  C. but not uniformly as occasionally such an experiment would fail. Subjectively, she had noted that her attacks were more



frequent when she was nervous. Objectively, we were able to bring on clear-cut mild attacks of ischaemia by psychic, painful or reflex stimuli as described in the history.

CASE III.—C. H. D., Strong Memorial Hospital, No. 46368, a salesman, aged fifty-eight, came to the hospital on April 20, 1931, having had a variety of treatments for Raynaud's disease during the past nine years. The onset of symptoms was abrupt, noted first in the toes but soon appearing in the fingers. The attacks consisted of sudden painless pallor of the digits, followed by prickling, numbness, and aching, and by an intense cyanosis. Moderate cold (as cool tap water) would bring on an attack. Spontaneous recovery occurred after a varying interval of one-half to two hours. The attacks were much more frequent in cold weather but he was not entirely free from them during the summer. The involvement was symmetrical, and soon after the onset of the trouble the fingers became more severely affected than the toes. Five years ago he had had a small spot of dry gangrene on the tip of the right ring finger lasting three months. Three years ago, there was a recurrence of ulceration at this point which did not entirely heal for two years. During the past winter the attacks had become more severe and in the feet the area of pallor and intense cyanosis had extended back over the metatarsals instead of being limited to the phalanges.

A significant point in the history was that the attacks were very often brought on by some unexpected event. Thus if he had been sitting quietly reading for an hour or more in a room of moderate temperature and the telephone suddenly rang, an attack would frequently be initiated. His fingers would become cyanotic before he could reach the telephone. This important effect of psychic stimuli in bringing on attacks was clearly demonstrated several times while the patient was in the hospital. Thus, the first trip to the constant temperature room (no cooler than the temperature of the room from which he had come); the introduction of a hypodermic needle; or even the description of a perineural injection that was to be carried out initiated sharp arteriospastic attacks. On the morning that the patient was to be shown to the students on rounds, his hands were exposed on the porch for an hour in order to bring out the typical appearance. In spite of the fact that it was a cool morning when we came to see him after this period of exposure the hands showed only a slight cyanotic tint, in fact as a demonstration of an attack of Raynaud's disease their appearance was at this point a complete failure. As soon as the group assembled about his bed the color of the hands immediately began to change and they became profoundly cyanotic within three minutes. The different attacks observed during his stay in the hospital varied in severity and duration. In them the whole hand became cyanotic but the fingers were most intensely so, the distal two-thirds being a bluish black in the more severe attacks. In a typical one of the latter, the right ulnar nerve was blocked with novocaine, anaesthesia being complete within ten minutes. By the time sensation in the ulnar areas was lost, blotches of red had appeared in the anaesthetic area of the palm and at the base of the little finger. During the next fifteen minutes these spread to include the whole of the ulnar area in the palm, the proximal and part of the middle phalanx of the little finger, and areas on the ulnar side of the proximal phalanx of the ring finger. (Fig. 4.) The rest of the hand as well as the other hand remained cyanotic. The terminal phalanx of the little finger became lighter in tint but did not lose its cyanosis. The temperature on this finger rose a maximum of  $2^{\circ}$  C. as compared with an increase of  $5^{\circ}$  C. in the anaesthetized area of the palm. The color of the distal half of the ring finger did not change from its profound cyanosis and no difference in the tint of its ulnar and radial sides was discernible although the former was anaesthetic and the latter was not. There was no increase in the surface temperature of the distal phalanx of this finger. The next day the right posterior tibial nerve was anaesthetized by perineural infiltration just below the internal malleolus. The cyanosis in the hands which was only moderate before the injection was intensified for several minutes immediately after this procedure. The patient had been under observation in the constant temperature

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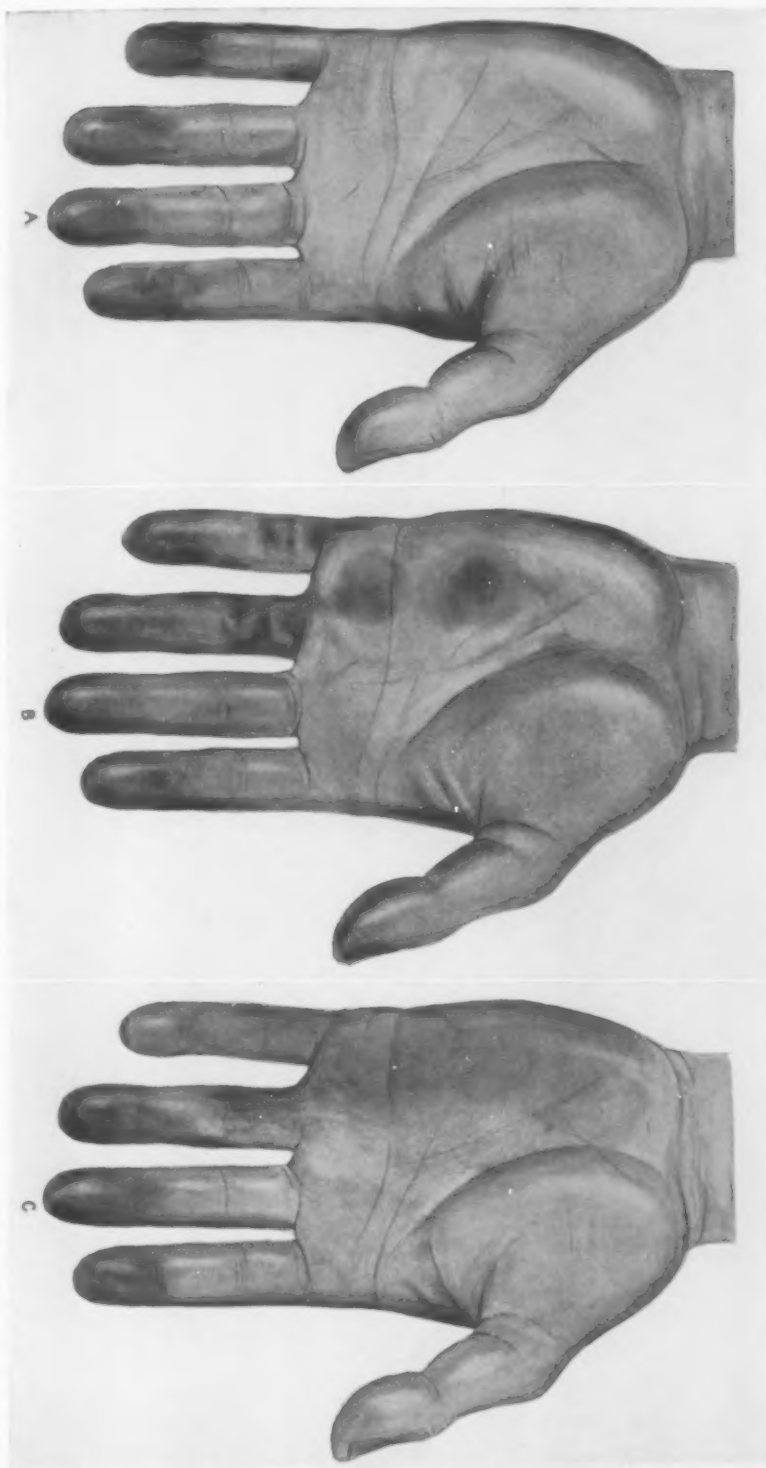


FIG. 4.—Case III. Raynaud's disease. Block of ulnar nerve. (A) Appearance of the hand before blocking the nerve. The whole hand is cyanotic, the extremity of each finger is extremely so. (B) Ten minutes after the nerve block, areas of bright red coloration have appeared in the ulnar region of the palm, in the proximal phalanx of the little finger, and on the ulnar side of the proximal phalanx of the middle finger. (C) One-half hour after ulnar nerve block, the red areas have spread to include the whole of the proximal phalanx of the little finger. This was the maximum improvement obtained. Note, particularly, however, that the distal half of the ring finger is unchanged and that the cyanosis in the distal phalanx of the little finger has not cleared up. There was complete anesthesia of the whole little finger and the ulnar half of the ring finger.

room for an hour previously and the soles of the feet were cold and markedly cyanotic. Anæsthesia was evident on the plantar surfaces of the foot and toes in twelve minutes. About five minutes later redness appeared on the heel and sole of the foot and slowly progressed over the metatarsal heads and onto the toes. The tips of the first, second and third toes remained blue for twenty minutes after anæsthesia was established, but the cyanosis here finally disappeared and the whole anæsthetic area became a bright pink in sharp contrast to the violet color which persisted unchanged on the sole of the other foot. (Fig. 5.) The temperature in the anæsthetized toes rose more slowly than normally but increased  $9^{\circ}$  C. and came to within one degree of the normal vasodilatation level.

This case likewise would be questioned as Raynaud's disease by some physicians because of his age and sex. There was nothing to make one



FIG. 5.—Case III. Raynaud's disease. Effect of blocking the right posterior tibial nerve. (A) Before injection. (B) Half an hour after injection, cyanosis has been displaced by hyperæmia everywhere except the second and third toes and the tip of the first toe. (C) Ten minutes later the cyanosis has disappeared from these residual areas. The cyanosis in the left foot (like that of A) remained unchanged throughout.

suspect thrombo-angiitis and in every regard the ischæmic attacks were characteristic. Here, again, the patient volunteered information that any unexpected event was likely to start an attack in his hands, and we were able objectively to cause obvious arterial spasm in the hands by psychic and by painful stimuli.

CASE IV.—F. C. B., Strong Memorial Hospital, No. 38360, a thirty-two-year-old clerk, came to the clinic in September, 1930. Since the age of twelve he has had attacks of extreme cyanosis in the hands and feet, brought on principally by exposure to cold. Ten years ago the second toe of the left foot became sore and ulcerated and for four years it was impossible to heal this lesion. Six years ago a left periarterial sympathectomy

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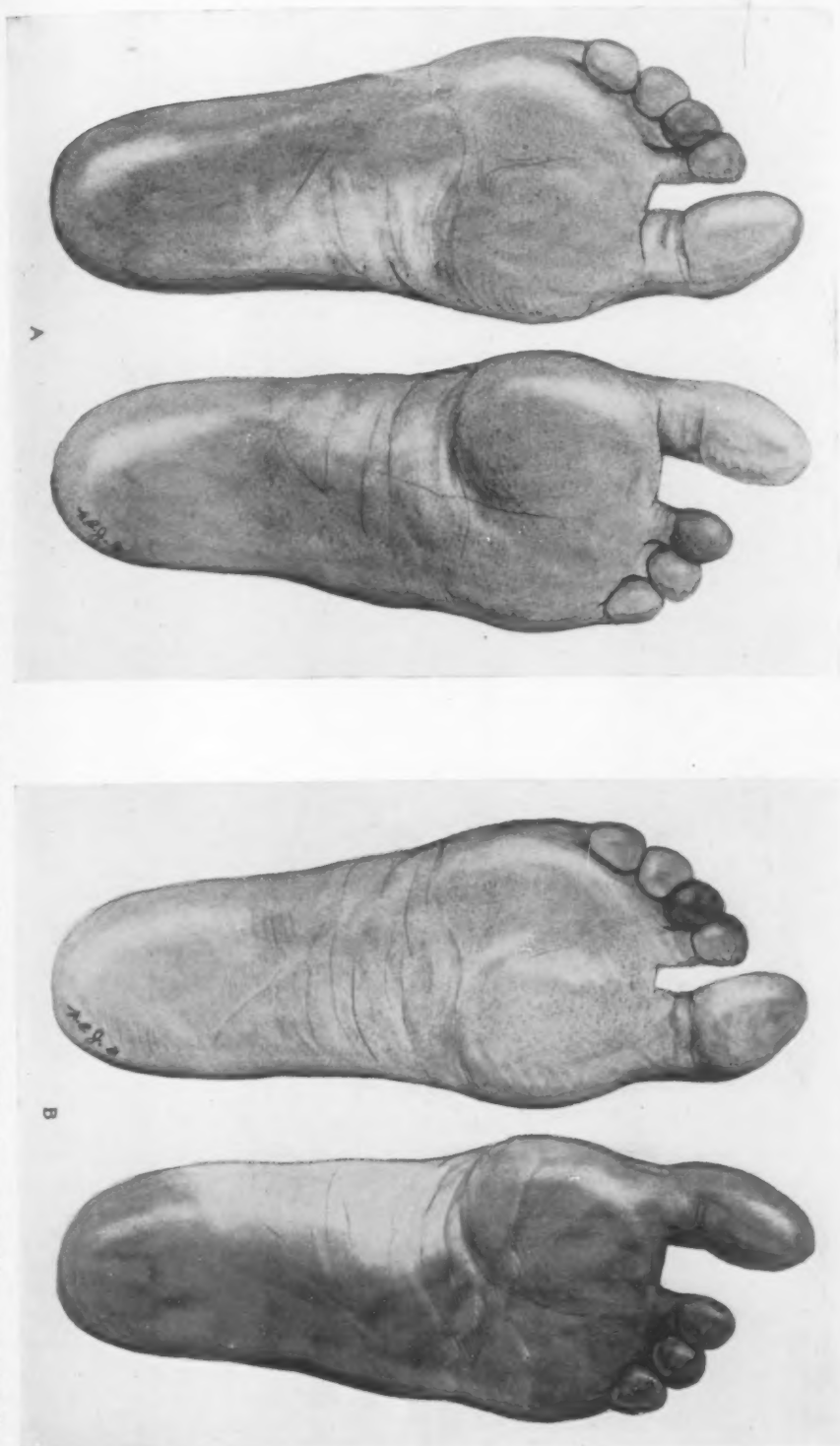


Fig. 6.—*Case IV.* Raynaud's disease. Effect of blocking the left posterior tibial nerve. (A) Appearance of the feet in an attack before nerve injection. (B) Forty minutes after the nerve injection, the whole of the anasthetic area of the left sole and toes has become a bright pink. The right foot had remained cyanotic with the exception of areas of spontaneous recovery on the first and fourth toes.

was done and when this did not improve the condition of the toe, the latter was amputated. The wound healed without complication. The lateral side of the left foot had ulcerated on several occasions but had always healed slowly. The hands also were subject to attacks of cyanosis but had not shown any trophic disturbance. The patient had to protect his hands and feet in cold weather. Following a very severe attack he had some pain.

The patient was obese, with scanty hair and a feminine habitus. His appearance suggested hypopituitarism though the X-ray of the sella was normal. We have seen the patient in several attacks during which the feet became extremely cyanotic and the hands markedly so. During the attack good pulsations in the major vessels of the extremities were palpable. An attack was brought on by exposure in a cold room. After the fingers had become deeply cyanotic and the soles of the feet an intense blue, the left posterior

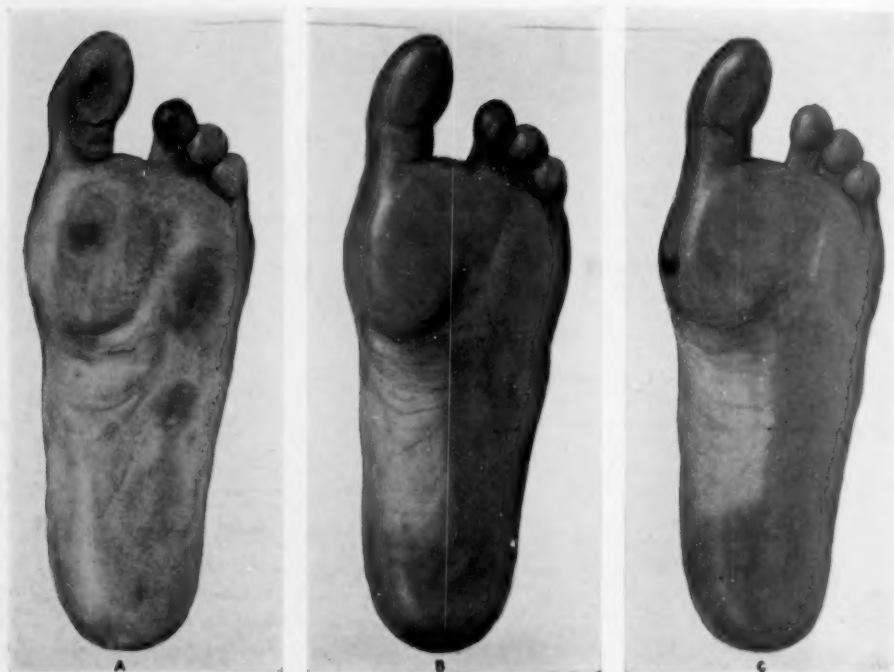


FIG. 7.—Case IV. Raynaud's disease. Effect of blocking the left posterior tibial nerve. This figure illustrates the stages in the recovery of the left foot shown in Fig. 6. (A) Ten minutes after injection of nerve. Areas of red appearing in the sole of the foot and the great toe. (B) About twenty minutes after nerve injection, cyanosis had disappeared completely from the whole sole of the foot and toes except the end of the third toe. This still was deeply cyanotic. (C) Thirty minutes after nerve injection, the cyanosis on the third toe had also completely disappeared.

tibial nerve was blocked by the injection of novocaine about it. In five minutes areas of bright red sharply contrasting with the deeply cyanotic background appeared on the sole of the foot and soon afterwards also in the middle of the plantar surface of the great toe. These islands of red color spread gradually until the whole plantar surface of the foot except the third toe was a bright red. About twenty minutes after the induction of the anaesthesia, this digit also slowly became as bright red as the rest of the foot. (Figs. 6 and 7.) The sole and heel of the right foot (uninjected) remained cyanotic throughout to the end of the two-hour observation period. Spontaneous recovery had occurred in a few areas on the toes, particularly the fourth toe which had become a fairly bright pink. The surface temperatures in the anaesthetic area came up to the normal vasodilatation level while the temperature of the toes on the unanaesthetized side remained between  $21.5^{\circ}\text{C}$ . and  $23^{\circ}\text{C}$ ., room temperature being  $20^{\circ}\text{C}$ . (Fig. 8.) This vasomotor



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test showed how completely the removal of the vasoconstrictor impulses relieved the vascular spasm in this patient's foot, even in the area on the third toe where this persisted much longer after anaesthesia was induced than in the other regions.

From our observations in Raynaud's disease we have been able to confirm in the main, the conclusions of Lewis, Kerr and Landis.<sup>7, 8, 9</sup> The attacks can usually be produced experimentally by exposing the extremities to a temperature of 15° C. When allowed to recover spontaneously from such an attack, the return of color is in a patchy distribution, small areas appearing as islands of redness in the cyanotic zone and gradually coalescing to form larger patches. There is no sudden let-up with a flush similar to that following the release of a tourniquet, but the spread is in general from the base slowly to the periphery of the digits as if by a seepage through

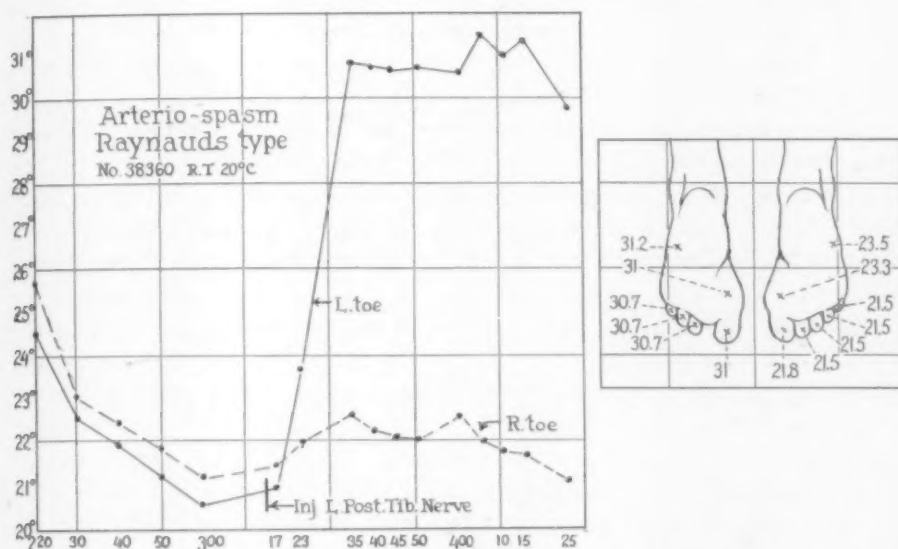


FIG. 8.—Case IV. Raynaud's disease. Effect on the surface temperatures of the great toes of blocking the left posterior tibial nerve. On the anesthetized side the normal vasodilatation level is reached.

small leaks. The recovery of color is in the reverse order to its appearance when the attack is produced. The surface-temperature readings in the involved digits indicate a slower return to the normal than in the uninvolved ones, but except in the severe cases the recovery is complete. In the latter there may be a failure to reach the normal vasodilatation level. We do not regard a three-phase color reaction as necessary in order to make a diagnosis of Raynaud's disease. The color of the skin is dependent on the state of the circulation through the subpapillary network; and the amount and degree of oxygenation of the blood in this network. If there is very little blood, there will be pallor or a yellowish tint; if the circulation is rapid, a red color; if stagnant with blood trapped in this zone, it will lose its oxygen and the cyanotic phase will result. When an attack is present, conduction nerve block will cause complete anaesthesia in the cutaneous area supplied by that

nerve. Recovery of color from the pallid or cyanotic to the pink phase takes place in the same patchy, slowly advancing way as it does when there is spontaneous recovery from an attack. The surface temperatures may slowly mount to the normal vasodilatation level; or the level may not be reached in certain severe cases.

It seems certain from these studies that the essential abnormality in Raynaud's disease is a local hypersensitiveness of the peripheral smaller arteries to cold as Lewis has emphasized. There is no sudden release of spasm as one would expect on paralyzing the central vasoconstrictor mechanism by conduction block anæsthesia. It may be significant, however, that spasms provoked by cold usually occur only in the areas which normally exhibit a vasoconstrictor gradient. From our observation we are inclined to stress the importance of the vasoconstrictor influence in this condition more than Lewis has in his writings. The voluntary subjective histories of initiation or accentuation of attacks by nervous factors in these patients has been substantiated by objective tests in our hands in a sufficient number of instances to make us believe that the vasoconstrictor mechanism also has an important rôle, though perhaps usually a secondary one. Thus our opinion is that Raynaud's disease is not primarily due to an abnormality in sympathetic innervation, yet that the majority of the attacks except in the most severe cases are initiated or accentuated by vasoconstrictor stimuli under the ordinary living conditions of these patients. We have not seen a case of Raynaud's disease where regional anæsthesia failed to cause some improvement in the circulation to the ischæmic extremity, though in the more severe cases, the most distal part of the extremity might remain uninfluenced by it. The more or less extensive relief afforded by surgical removal of vasoconstrictor influences also tends to bear out this opinion. We feel, therefore, that there is a proper justification for radical surgical attack on the sympathetic system in severe cases provided that it can be shown by appropriate tests that the surface temperature in the involved digits can be brought nearly to the normal vasodilatation level. (This is also in agreement with Lewis's opinion though he does not give it much prominence.) On the other hand, it is futile to operate on every case of Raynaud's disease with the expectation of a complete cure. When the hypersensitiveness to cold is so pronounced that release of vasoconstriction by appropriate tests fails at ordinary room temperatures to raise significantly the surface temperatures in the digits, a poor result must be inevitable from any operative procedure. We believe, then, that in typical Raynaud's disease there is a dual control operating to cause spasm of the peripheral vessels. The essential defect is a hypersensitiveness of the peripheral vessels to cold. But the vasoconstrictor influences are powerful in bringing on and keeping up attacks and their removal may be effective in prevention.

*Angiospasm in Functional and Organic Nervous Disorders.*—The functional and organic nervous system disorders may at various times exhibit derangements of the vasomotor mechanism to the extremities. We have

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selected a few instances to illustrate the increased vasoconstrictor response of this type. It is interesting to note that these patients also show an intensification of their pain and vasoconstriction on exposure to cold. This fact would hardly seem to be dependent on a constitutional local hypersensitivity of the peripheral vessels to cold and serves to emphasize the involvement of the sympathetic nervous system in many such conditions. It is only necessary to recall the cold, clammy extremities in patients with long-standing paralyses of anterior poliomyelitis; or the changes in surface temperatures in the later stages of the hemiplegic extremities, as also in some cases of spina bifida<sup>2</sup> to realize the broad field of this vasoconstrictor activity which should be explored further.

CASE V.—A. V. S., Strong Memorial Hospital, No. 43979, came into the clinic in February, 1931, on account of pain in the right knee and coldness of the right foot. Three years ago the patient struck her right knee going up a flight of stairs. This was not a particularly severe trauma. Beginning a few weeks after this, she noted pain in this knee and for the last two years has had weakness of the right leg, particularly on walking. There has been an associated coldness of the right foot which the patient has noted repeatedly. On examination she had definite atrophy of the right soleus and gastrocnemius, a bilateral positive Babinski's sign, gross fibrillary twitchings in both quadriceps muscles. After the patient's feet had been exposed in a moderately cold room, the right foot was obviously cooler on palpation than the left. Measurement showed that when the patient was in a fairly warm room little difference was evident in the two feet. But on exposure in a cool room (18° C.), a difference of 2° C. between the temperatures of the two feet would be brought out. This was noted on several occasions, the right always being the colder.

The patient apparently had an organic nervous disease of the type of amyotrophic lateral sclerosis with more marked manifestations in the right leg. Accompanying this condition there was an increased vasoconstrictor activity which under certain circumstances was latent but which could be brought out under the proper conditions, especially in a cool room.

CASE VI.—F. D., a vigorous laborer, sustained a fracture of both bones of the left lower leg two years previously. After the cast was removed it was found that the patient had anæsthesia in the foot, together with loss of motor control of its movements. He was referred for consultation because of the fact that associated with these symptoms he had an easily palpable difference in the temperatures of the two feet, the anæsthetic one being constantly cooler. The fracture has been completely healed for one and a half years. In spite of the patient's inability to flex and extend the toes or the foot at the ankle on the left side, he had no significant atrophy and no toe drop on walking. There was complete anæsthesia of the foot and irregular regions of anæsthesia and hypoaesthesia extending as high as Poupart's ligament, the distribution of which had no definite pattern of either peripheral nerve or nerve-root involvement. It was obvious that this was a functional nervous disorder to be classed as a post-traumatic hysteria.

It is of interest that although the area of distribution of this nerve was completely anæsthetic, when the posterior tibial nerve was touched with a needle just below the internal malleolus, the patient experienced a sharp pain. Apparently the unexpected stimulation of the nerve in this manner produced the normal response to pain. The latter was inhibited in his condition upon the peripheral stimulation in the manner with which the patient was familiar.

The interesting feature in regard to this patient was that the surface temperatures in the left toes were constantly two degrees cooler than in the right. After blocking the left posterior tibial nerve, however, the temperature of the left foot came up to the normal vasodilatation level and there was no evidence suggesting organic disease of the blood-vessels. (Fig. 9.) Evidently then, in this case of post-traumatic hysteria, there was an increased vasoconstrictor tonus in the involved foot. It would be of interest to know whether hysterical manifestations in an extremity are regularly accompanied by a similar increased vasoconstrictor activity or whether this was a fortuitous feature in this instance.

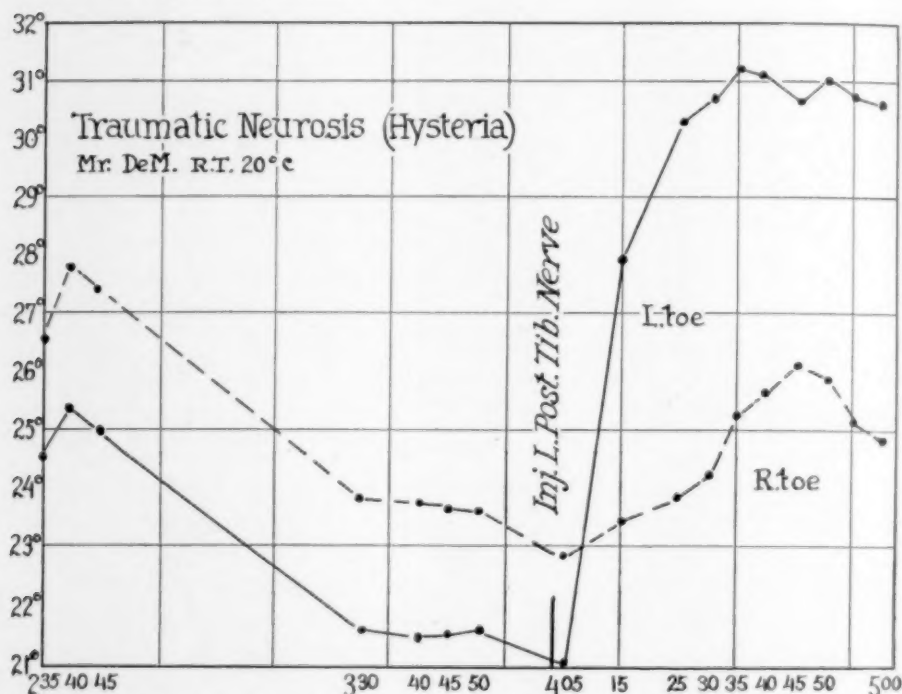


FIG. 9.—Case VI. Traumatic hysteria. Surface temperatures on the toe of the affected side remained 2° C. below that of the uninvolved side. After blocking the left posterior tibial nerve the temperature rises sharply above that of the normal foot and reaches the normal vasodilatation level.

CASE VII.—M. S., Strong Memorial Hospital, No. 8919, a sixty-three-year-old housewife, with moderate general arteriosclerosis and occasional symptoms of cerebral arteriosclerosis, had a Colles fracture of the left wrist in April, 1930. Following this she had numbness and pain in the left thumb, the index and middle fingers. The pain increased and became burning in character. The application of cold to the peripheral area produced very intense pain, so that at home she constantly wore a woolen sock over this hand. This effect of cold was verified in the clinic by putting the patient's hand in water at 13° C. for ten minutes which produced an intense pain and from which the involved fingers recovered their temperatures more slowly than the corresponding areas of the opposite hand. This was a typical causalgia of so severe a degree that alcohol injection was resorted to. The median nerve was blocked just above the wrist; it was found that this nerve had become adherent to the callus at the site of the fracture in the ulna. Anaesthesia has persisted and the patient has remained free of pain for six months since

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this procedure. The anæsthetic areas on the fingers have remained colder than the corresponding areas of the opposite hand.

This patient illustrates very nicely the hypersensitivity to cold induced by local involvement of a peripheral nerve. This hypersensitivity showed itself by the pain and by the increased vasoconstriction, both being elicited by cold applied to the area of distribution of the involved nerve.

*Angiospasm Consecutive to Trauma.*—The fact that trauma was also noted in the histories in Cases VI and VII leads us to the consideration of the next group of patients who apparently have no organic or functional background except that they date all their angiospastic difficulties to some trauma. This traumatic group of vasoconstrictor spasms is an important one which is only imperfectly differentiated at present. Undoubtedly many examples of it are being overlooked today. Leriche<sup>10, 11, 12</sup> has particularly stressed its importance. We have recorded two examples of traumatic vasoconstrictor spasm in a previous communication.<sup>2</sup> We have repeatedly observed similar phenomena after different types of trauma, such as fractures, sprains, severe contusions, *etc.*, as well as cases where the main nerve trunks are implicated as in causalgia discussed in the preceding section. Ipsen<sup>13</sup> has also noted that the skin covering amputation stumps exhibits an accentuation of vasoconstriction, giving colder surface temperatures than is customary for that level of skin area.

The following two case histories illustrate certain important points that we should like to emphasize in regard to this form of angiospasm consecutive to trauma.

CASE VIII.—M. S. M., Strong Memorial Hospital, No. 3110, a twenty-one-year-old saleswoman, came to the hospital on account of pain in the left ankle. Nine years previously this ankle had had an injury with the tine of a pitch-fork, and since that time she had more or less pain in this ankle which bothered her especially on walking. The Röntgen-ray showed an area of increased density on the surface of the astragalus. An exploratory arthrotomy was performed and the area was curetted out on December 17, 1926. Before operation there had been a little swelling and œdema present over the anterior surface of the left ankle but no abnormal coloration of the skin and no difference in the appearance or temperatures of the feet was noted. The immediate post-operative reaction was not abnormal. There was a moderate amount of swelling and pain in the ankle. The unusual element in the case, however, was that when the patient was allowed up on crutches two weeks after operation, the discomfort in the foot and swelling around and below the ankle increased and the foot became extremely cyanotic and much cooler than on the opposite side. Exposure to cold accentuated the cyanosis and coldness of this foot. She was seen repeatedly over the next six months. The same tendency to swelling, cyanosis and coolness of the foot remained unaltered for four months and then gradually began to diminish. Whether or not this was a mere coincidence real improvement came with the advent of warmer weather. At no time was there any evidence of a complicating infection.

We have seen many other examples of a similar reaction to trauma in the extremities whether accidental or operative. Usually this response is not as extreme as in the case cited, but it is frequently an annoying symptom for several months. It is apparently due to an increased vasoconstrictor tonus in the involved extremity.



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CASE IX.—C. A. E., Strong Memorial Hospital, No. 30176, a forty-three-year-old laborer, injured the index, middle and ring fingers of the right hand on October 16, 1929, by getting them caught between two heavy stones. There was considerable pain and nausea following the accident, but the skin was not broken and the patient kept on working. No particular symptoms were noted by the patient for four or five days at which time the injured fingers began to ache and became extremely sensitive on exposure to cold. Tactile stimuli in this area also became painful. After exposure to cold, the involved fingers became a deep blue. Two weeks after the accident he stopped work on account of the pain in these fingers. We saw him first on December 3, 1929, when he had come in out of the cold weather. The distal two phalanges of the ring and middle fingers on the right hand were a very deep blue and at first glance appeared gangrenous. The rest of the hand was of normal color. On putting his hand under the warm tap water the intense cyanosis disappeared completely and was replaced by a bright pink color. On another day in a warm room a difference of three degrees in

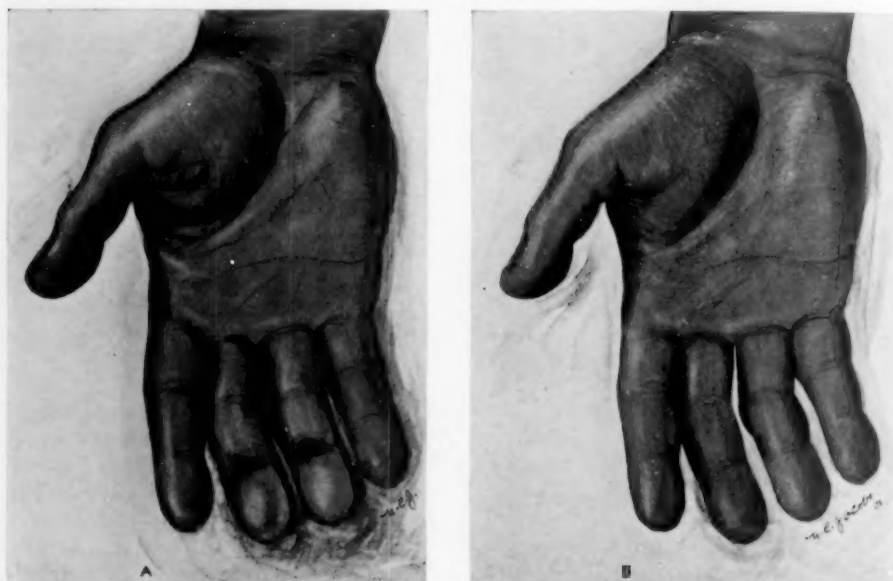


FIG. 10.—Case IX. Angiospasm, post-traumatic. (A) Fifteen months after trauma the effect of cold brings out ischemic areas on the ring and middle fingers of the right hand. (B) The angiospasm entirely subsides at ordinary room temperature ( $19^{\circ}\text{C}$ .).

the temperatures of the index, middle and ring fingers from the corresponding ones on the left hand was measured, while the temperatures of the little fingers were within one degree of each other. In a cold room this difference in temperatures between the involved and uninvolved fingers became considerably more. Hot and cold contrast baths to the part and Bier's hyperæmia were prescribed. Under this treatment his fingers improved somewhat and with the coming of warmer weather in the spring ceased to bother him. The following winter, however, with the advent of cold weather, he had a recurrence of his trouble limited to the terminal phalanges of the right ring and middle fingers. In these areas the ischæmia brought on by cold become so intense that anæsthesia was produced, on one occasion to such a degree that, without realizing it, he burned the tip of his middle finger.

On January 30, 1931, fifteen months after the original contusion, he came into the hospital on a cool morning with an attack of intense pallor involving the terminal phalanges of the right index and middle fingers with a narrow band of marked cyanosis proximal to this. (Fig. 10.) This area was  $6^{\circ}\text{C}$ . colder than the corresponding area

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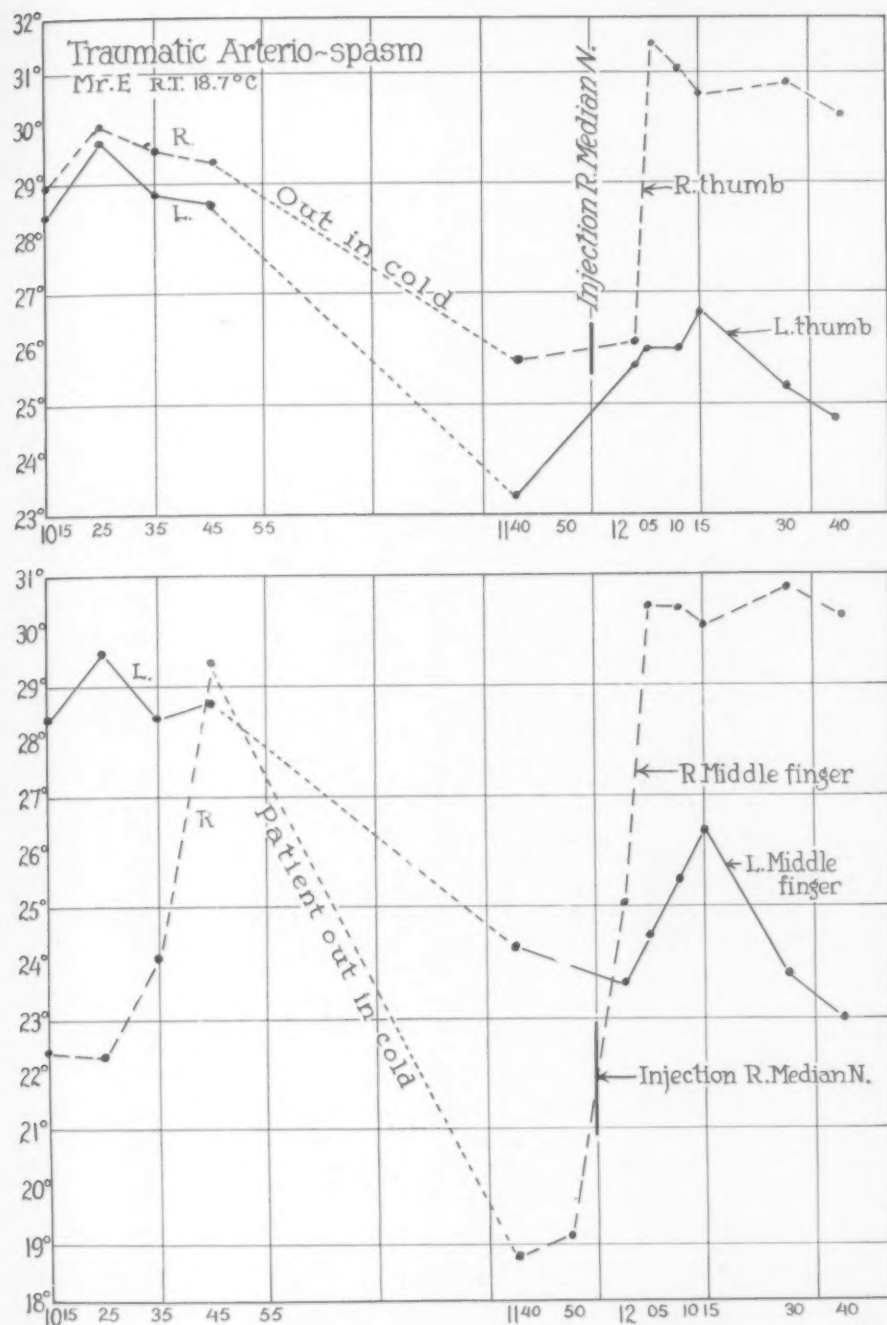


FIG. 11.—Case IX. Angiospasm, post-traumatic. Temperature determinations on the same patient as Fig. 10. On coming in out of the cold, note that the right middle finger is 6° C. cooler than the left. At room temperature the spasm in the right finger rapidly subsides and its temperature comes up to the same level as on the opposite side. After exposure to cold, this temperature difference is brought out again. Upon injection of the right median nerve the temperature of the right middle finger comes up to the normal vasodilatation level and is four degrees above the temperature of the left (normal) middle finger.

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of the opposite hand. At ordinary room temperature ( $19^{\circ}$  C.) however, this angiospasm rapidly subsided and the temperature in this area came up to the same level as on the opposite side. The patient was again exposed to cold bringing back the difference. The right median nerve was blocked and the temperature rose rapidly to the vasodilatation level in the middle fingers going  $4^{\circ}$  above the temperature of the corresponding finger on the uninvolved and uninjected side. (Fig. 11.) The patient has been followed and, with the coming of warm weather again, is free from symptoms.

Some of the outstanding points to be noted in angiospasm following trauma are: (a) The hypersensitivity to cold; (b) the long duration of the



FIG. 12.—Case X. Venospasm. The principal lesion in the attack is on the left middle finger which is tense, congested and elevated above the surrounding level.

vascular spasm after the acute affects of the trauma have subsided and the injured tissues have been repaired by scar, and (c) the fact that this predisposition to angiospasm may pass into a latent stage and remain dormant for a long interval to be brought out again by certain conditions, particularly by cold. The frequency with which some degree of angiospasm follows many different types of trauma convinces us that an increased vasoconstrictor activity is a fundamental response to trauma and scar formation. We see this reaction definitely in causalgia when a nerve trunk is involved in the scar;

## ANGIOSPASTIC SYNDROMES IN EXTREMITIES

otherwise in the process of injury and repair it occurs without this obvious cause, though it is possible that the terminal nerve fibres are caught in the scar tissue. The cause for a trauma to result in a severe angiospasm or a long-standing susceptibility to it in one individual while in another this reaction quickly disappears is unknown. There is no definite correlation between the degree of the trauma and that of the angiospasm. It is probably true that a vasoconstrictor hypersensitivity is present in a latent form much longer and more commonly than is realized. Such a form is often passed over unrecognized as it requires the proper physical conditions to bring it out. The aching of scars on exposure to cold is probably to be explained on this basis. In regard to the treatment of those angiospasmic consecutive to trauma, we are at present being extremely conservative because most of them usually clear up under such a plan. We recognize the fact that certain cases may require temporary or permanent removal of sympathetic innervation. At present there are no satisfactory criteria to allow the proper selection of such cases. This group deserves further intensive study, as it is one of great clinical importance.

*Venospasm.*—An unusual type of vasomotor disturbance recently came under our observation.

CASE X.—P. W., Strong Memorial Hospital, No. 41961. This patient was a forty-nine-year-old housewife, who was admitted to the hospital on account of painful swollen areas on the left hand. The trouble began four weeks previously, when, following a manicure, she noted throbbing in the left middle finger. The pad of its distal phalanx became swollen, purplish, and exquisitely tender and painful. Since then she had had other similar areas at the base of the thumb and on the index finger. Neither of these had bothered her as severely as the one on the middle finger. The pain came in attacks preceded by swelling and intense congestion in the involved area. The congestion on the middle finger had become so intense that on two occasions a slight incision into it was made by other physicians. No pus was found at either time. The attacks of pain were particularly apt to come in the evening.

On examination, there was an intensely swollen congested area occupying about half of the palmar surface of the distal phalanx of the left middle finger. (Fig. 12.) There was also an area at the base of the thumb which was congested but not elevated. Measurement of the surface temperatures over the congested area showed it to be between one and one-half degrees warmer than the corresponding area on the opposite hand. This difference on the two sides was accentuated by immersion in water at 16° C. for ten minutes and the initial temperature was recovered over the involved area much more quickly. (Fig. 13.) This combination of paroxysmal intense congestion, purplish discoloration and evidence of increased warmth in the involved region (without infection) seems explicable only on the basis of a venospasm. The pain during the attack which the patient describes as throbbing in character is apparently due to the intense congestion in the area. This was so decided that it caused a marked local elevation. Either extreme of temperature was painful to the patient. The pulsations of the digital arteries of the involved finger were easily palpable, in fact, they seemed to be greater in the left middle finger than in the right. Careful search was made for evidence of any lesion that could be causing an irritation of the median nerve or its roots without finding any such cause. Our diagnosis was vasomotor neurosis, predominantly venous. With the patient quiet in the hospital the attacks of local swelling and pain diminished but later information in regard to the patient is to the effect that she is still troubled by them.

We have advised the patient to have the left median nerve blocked by novocaine in order to determine whether this would relieve the congestion and pain but she did not consent to this.

Examples of true angiospasm on the venous side are certainly rarely recorded in the literature, and little is known about their cause and natural history. In this case it was our opinion and that also of the neurologic consultant that the venospasm was the expression of an underlying psychoneurosis. On the therapeutic side our endeavors were directed against the latter condition; but she did not stay under our care long enough to determine the final result.

## CONCLUSIONS

(1) There are several types of angiospasm which can be recognized and

separated into major groups as follows: (a) In organic vascular disease, (b) idiopathic paroxysmal (Raynaud's disease), (c) dependent upon organic or functional nervous diseases, (d) consecutive to trauma, (e) venospasm.

(2) In Raynaud's disease the fundamental abnormality is a hypersensitivity of the peripheral arteries to cold. However, vasoconstrictor impulses play an important rôle by initiating and accentuating many of the attacks. Consequently, the advisability of removing the sympathetic innervation can be determined by the effect of regional anaesthesia in releasing the spasm during an attack.

(3) Organic and functional nervous disorders frequently are accompanied by an accentuated vasoconstrictor tone locally.

(4) Trauma in the extremities may be followed by an arterial spasm, frequently associated with pain. This is probably due to vasoconstrictor impulses induced by reflex afferent stimuli from the traumatized area. We

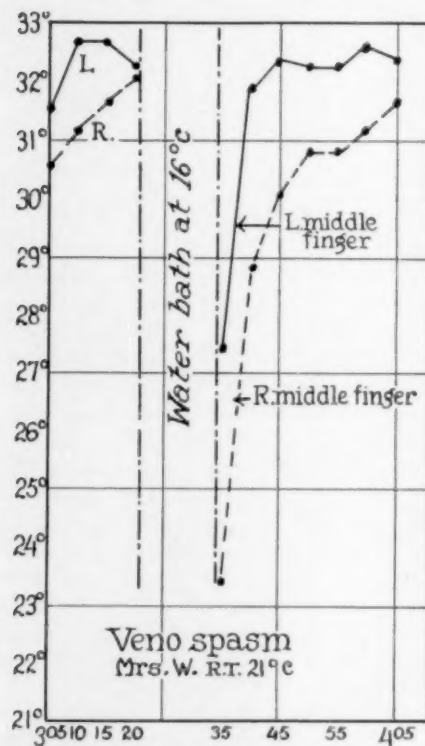


FIG. 13.—Case X. Venospasm. Surface temperatures on the middle fingers. Note that the involved side is at a higher temperature both initially and immediately after immersion in a cold-water bath; also that it recovers its pre-immersion level much more quickly.

believe that such a reaction is a fundamental response incident to trauma and scar formation. There is an individual variation in the degree of manifestation of this reaction and it may be present as a latent hypersensitivity to cold.

(5) Evidence is presented that angiospasm affecting principally veins occurs as a clinical entity.



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### REFERENCES

- <sup>1</sup> Morton, J. J., and Scott, W. J. Merle: The Measurement of Sympathetic Vasoconstrictor Activity in the Lower Extremities. *Jour. Clin. Invest.*, vol. ix, p. 235, 1930.
- <sup>2</sup> Morton, J. J., and Scott, W. J. Merle: Studies on the Activity of the Lumbar Sympathetic Nervous System. *ANNALS OF SURGERY*, vol. xcii, p. 919, 1930.
- <sup>3</sup> Scott, W. J. Merle, and Morton, J. J.: Obliteration of Vasoconstrictor Gradient in the Extremities Under Nitric Oxide-Oxygen, Ether, and Tribromethyl Alcohol Anæsthesias. *Proc. Soc. Exp. Biol. and Med.*, vol. xxvii, p. 945, 1930.
- <sup>4</sup> Morton, J. J., and Scott, W. J. Merle: Methods for Estimating the Degree of Sympathetic Vasoconstriction in Peripheral Vascular Diseases. *New Eng. Jour. Med.*, vol. cciv, p. 955, 1931.
- <sup>5</sup> Scott, W. J. Merle, and Morton, J. J.: Sympathetic Activity in Certain Diseases, Especially Those of the Peripheral Circulation. *Arch. Int. Med.* (In Press.)
- <sup>6</sup> Scott, W. J. Merle, and Morton, J. J.: The Differentiation of Peripheral Arterial Spasm and Occlusion in Ambulatory Patients. *J.A.M.A.* (In Press.)
- <sup>7</sup> Lewis, Thomas, and Kerr, William J.: Experiments Relating to the Peripheral Mechanism Involved in Spasmodic Arrest of the Circulation in the Fingers. A Variety of Raynaud's Disease. *Heart*, vol. xv, p. 8, 1929.
- <sup>8</sup> Kerr, William J.: Recent Experimental Studies on Raynaud's Disease. *Trans. Assoc. Amer. Physicians*, vol. xlv, p. 189, 1930.
- <sup>9</sup> Lewis, Thomas, and Landis, E. M.: Some Physiological Effects of Sympathetic Ganglionectomy in the Human Being and Its Effect in a Case of Raynaud's Malady. *Heart*, vol. xv, p. 151, 1930.
- <sup>10</sup> Leriche, R.: Periarterial Sympathectomy for Post-traumatic Reflex Nervous Disturbances. *Lyon Chir.*, vol. xiv, p. 754, 1917.
- <sup>11</sup> Leriche, R.: De l'importance en pathologie et en thérapeutique des réaction vasomotrices post-traumatique. *Medicine*, vol. ix, p. 341, 1928.
- <sup>12</sup> Leriche, R.: Problem of Osteo-articular Diseases of Vasomotor Origin; Hydrarthrosis und Traumatie Arthritis; Genesis and Treatment. *J. Bone and Joint Surg.*, vol. x, p. 492, 1928.
- <sup>13</sup> Ipsen, Johs: Recherches sur les arteres a l'etat pathologique. *Acta Chir. Scandinavica*, vol. lxxv, p. 341, 1929.

## THE DIAGNOSIS AND PRINCIPLES OF TREATMENT OF CARCINOMA OF THE COLON AND RECTUM

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WE HAVE been discussing a subject which should command more attention than has been given to it by the medical profession in general, and this lack of attention starts in the medical schools many times. The importance of a disease should be determined by the value of treatment in prolonging life and in making it more comfortable for the patient rather than by the number of cases seen. If we compare the results of treatment in cancer of the colon and rectum in prolonging life and making it more comfortable with the results of treatment of other serious diseases, we must come to the conclusion, I believe, that it stands high on the list of important diseases. That the disease should stand high among important diseases is shown by the fact that although the diagnosis is made so late in the course of the disease (25 per cent. to 50 per cent. of those seen are operable), between 45 per cent. and 50 per cent. live in comfort for five or more years.

That carcinoma of the colon and rectum is not considered one of the important diseases is well illustrated by the Massachusetts statistics. There are, in Massachusetts, 11,000 deaths from carcinoma each year, and of these about 12 per cent. are in the intestine; that is, about 1,200 cases of carcinoma of the colon and rectum die each year. After considering the work of various hospitals, it is difficult to believe that there are more than 150 radical operations, probably less, each year. It is evident, therefore, that about 10 per cent. of the patients with this disease are given a chance for life and comfort. It is possible that 50 per cent. of the patients in the state get either a radical or a palliative operation; many, therefore, are given no opportunity to be more comfortable and undoubtedly many get no consideration by a competent authority. It is probable that not more than 60 patients out of the 1,200 live five or more years.

The waste of life then is very considerable not to mention the great amount of suffering that might be avoided, largely because the physicians and surgeons of the state do not have it impressed upon them that cancer of the colon and rectum is a disease of importance, because it can be treated with considerable success. It would not be a wild dream to believe that more than 75 per cent. of all cases would be suitable for radical operation if general interest could be aroused, but, of course, it is useless to expect any sudden change in the interest shown in these cases or in the ability to diagnose them. The surgeon must first become interested in these cases in order to stimulate others. He must show physicians that he can operate with a reasonable mortality and must be able to show that patients live comfortably for a reason-

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able length of time. We have scattered over the country at present a small but increasing number of surgeons who take an interest in the subject.

Up to quite recently patients, physicians, and, I am sorry to say, surgeons have felt perfectly hopeless about the value of operation for carcinoma of the colon and rectum. In consequence of this lack of interest by the surgeons, no interest has been taken in the early diagnosis, in consequence of which patients have been treated by palliative operations only. While a positive diagnosis may at times be difficult, it is quite evident that it is not the difficulty of diagnosis but rather a lack of interest which is responsible for the great delay in the treatment of these cases. Recently some interest in this condition has been aroused in a small group of physicians, and unless the surgeons rise to the occasion and are ready to attempt radical operations, these physicians will soon lose interest and we shall drop back to where we were a few years ago. A recent paper stimulated the physicians of a section of Massachusetts to look for these cases. They were rewarded by finding several, but as one of the physicians complained, "I have sent my cases to surgeons, but they have attempted nothing but a colostomy on any one of them."

While interest in this disease is the most important factor in early diagnosis, we cannot hope to progress much so long as the brains of medical students are filled with exceedingly interesting (at least to the teacher), rare, and hopeless cases instead of teaching them the diagnosis of carcinoma of the colon and rectum. At a recent meeting in a teaching hospital a group of most unusual and hopeless cases were shown, and the surgeon assured us that he had arranged to have hæmorrhoids and fistulæ sent to another non-teaching hospital so that he could take in the unusual cases. When we consider that about 75 per cent. of the cases of carcinoma of the rectum are first diagnosed as hæmorrhoids, how are the students to learn anything about carcinoma of the colon or rectum in the teaching hospital?

The diagnosis of these conditions should be of great importance to physicians as well as surgeons. The usual list of symptoms as given in the textbooks is not sufficiently clear to the average physician for him to make a diagnosis, because many of them are of little or no value. If it could be taught that any change in bowel habit or sensation or bleeding from the rectum is suggestive of malignant disease of the colon or rectum, it would not be necessary to burden students and physicians any further. A group of students going out with this impressed upon them would soon teach it to their patients and difficult cases could then be sent early to competent authorities for diagnosis. The great difficulty is that this statement is so simple few would really accept it for fear of disturbing patients if there was no disease present.

The question of blood in the stool is of great importance when properly considered and especially is it of importance to the internist and family physician who are the first to see these cases, and yet it is so firmly impressed upon them that hæmorrhoids are the important cause of bleeding that blood

in the stool is of little or no value in diagnosis to the average physician or layman.

If all schools could send their students out with the idea that bleeding from the rectum means carcinoma of the colon or rectum until it is definitely proved in a particular case that it is not, a great advance would be made. I asked a class of 100 students the other day the most important cause of bleeding from the rectum and was told that it was hæmorrhoids.

Much has been said recently about bleeding in cases of diverticulitis of the colon. So far as can be made out from statistics, bleeding associated with diverticulitis of the colon alone occurs in about 5 per cent. of these cases. It is evident, therefore, that great care must be taken to avoid overlooking carcinoma of the colon when there has been bleeding and a diagnosis of diverticulitis has been made by X-ray. In my own cases if I had depended on the X-ray diagnosis of diverticulitis with bleeding, an error would have been made in 75 per cent. of the cases, while if operation had been carried out in all these cases, the operation would have been an error in but 25 per cent. It is exceedingly dangerous to make a diagnosis of diverticulitis of the colon even with the aid of the X-ray when there is bleeding associated with it.

Symptoms which are still spoken of as of great importance are: The "ribbon" stool, constipation, alternating constipation and diarrhœa, diarrhœa alone, loss of weight, and pain. The ribbon stool may be thrown out as of no value. Constipation in these days of oils often passes unnoticed. It may be true that there is alternating constipation and diarrhœa, but so long as the patient does not recognize it, why should we consider it of importance? The patient may become constipated, but if he does he frequently takes oil which relieves, usually without diarrhœa. At times the constipation may be more marked; he then takes a cathartic and has several movements which he attributes to the cathartic and he does not speak of it as diarrhœa, nor does he appreciate that it is alternating constipation and diarrhœa. When the growth is low or causing marked obstruction, there are often many small movements or the patient goes to stool frequently to get rid of mucus and usually blood, but he does not recognize this as diarrhœa. Loss of weight is of little value as a symptom as it rarely occurs until after the obstruction is marked. There is then at times loss of weight due to loss of appetite, but rarely loss of weight due to the disease. Pain does occur frequently, but it is before the patient reaches the physician usually. Later in the course of the disease the patient does not complain of pain, but will admit that there is much disturbance from gas, not pain. Occasionally there are repeated attacks of pain with comfort between the attacks. These are frequently overlooked or considered to be of no significance unless they are unduly prolonged. It will be seen, therefore, that many of the symptoms as given in the older textbooks are really of little value in making an early diagnosis.

If carcinoma of the rectum is suspected, the diagnosis can be made, in 100 per cent. of the cases presenting themselves, by digital or sigmoidoscopic examination. I have no hesitation in urging that no X-ray examination be made

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until carcinoma of the rectum has been ruled out by these examinations, for why should we use an uncertain method in place of an absolutely sure one?

In suspected carcinoma of the colon our greatest aid to diagnosis is undoubtedly the X-ray, but it must always be used in connection with the history and physical findings. X-ray examination alone leads to many errors in spite of the fact that many clinics report a correct diagnosis in from 85 per cent. to 95 per cent. of the cases examined. This does not mean that the X-ray alone has made a correct diagnosis in such a high percentage, but probably means that the surgeon has made a correct diagnosis with the history, physical findings and X-ray examination, while many depend upon the X-ray examination alone.

It is my belief after seeing many X-ray reports on these cases that a correct diagnosis is made in not more than 75 per cent. of the cases by the average roöntgenologist. In the clinics in which the higher percentages of correct results are made, it is probable that no allowance is made for the cases which leave that clinic with a clean bill of health and are later found to have carcinoma of the colon, nor does it account for the cases which are diagnosed as diverticulitis but later are proved to be carcinoma.

The percentage of correct results in many clinics in carcinoma of the rectum is so low that an X-ray should not be used. Proper digital and sigmoidoscopic examinations will always make a diagnosis of carcinoma of the rectum and rectosigmoid. It is undoubtedly true that sigmoidoscopic examinations have been much neglected in carcinoma of the colon as well as of the rectum. The growth cannot always be seen, but frequently the determination of blood in the rectum and the direction from which it comes is of great value. Frequently when the growth cannot be seen, a fixed mass can be felt with the sigmoidoscope. The presence of ulcerative colitis, polyps, tuberculosis, and other ulcerations in the rectum may be found an aid in ruling out carcinoma above. Examination of a patient who has been bleeding recently will often aid one in determining that the blood is coming from the hæmorrhoidal area even though the hæmorrhoid is not bleeding at the time.

Papillomatous and adenomatous polyps, when found, should be considered as potential or actual carcinomata. It is impossible in many cases to determine as to whether or not they are already carcinomatous by removing a section. A useful method of determining the character of the growth is to remove it with the high frequency cautery and then examine the base with a proctoscope at weekly intervals. If the base heals smoothly and remains so, the diagnosis of simple polyp may be made, while if a granulating area remains, a section can be removed and the character of the growth determined accurately.

A source of error in these examinations is the fold on the anterior surface of the rectum at about 15 centimetres above the external orifice when the patient is in the knee-chest position. It is quite possible to cover a polyp or a small carcinoma here with the end of the sigmoidoscope and overlook it entirely unless great care is taken to examine as the instrument is withdrawn.



It is my opinion that more errors are made because of inability to see the whole surface of the rectum and lower sigmoid than for any other reason. It is not sufficient to have the bowel free from large masses of faecal matter; the mucous membrane must be carefully wiped in order not to see ulcerations where there are none. Ulcerative colitis has been reported when frequent movements with blood are present because of this error.

In the final summing up of a case in which carcinoma of the colon is suspected, it must not be forgotten that an exploratory operation is not a serious matter. We must not forget how easily we advise operation for a suspected chronic appendix or for a so-called chronic cholecystitis. It is of much greater importance to explore when carcinoma is suspected.

In regard to the treatment of carcinoma of the colon and rectum I feel that there should be some standardization or at least some agreement as to the fundamental principles of the treatment of carcinoma of the colon and rectum. I am quite in agreement with Doctor Turner when he said at the meeting of the American College of Surgeons last October: "Personally I have a great distrust of so-called standardization in dealing with human beings and pathologic conditions." I feel, however, that we must agree upon certain fundamental principles. Another statement which Doctor Turner made in the same address proves the necessity for coming to some agreement. He said: "The history of surgery of malignant disease is neither so discouraging nor so discreditable as many would have us believe, for it shows that when efforts of the surgeon have been sufficiently thorough, the results have often been commensurate with the sacrifice which the patient has had to make."

The fundamental principle to be settled is: What is a "sufficiently thorough" operation? This has been answered in the past and even up to the present time by two opposing groups. The first group states that carcinoma of the colon and rectum metastasizes late or not at all and therefore a local operation is sufficient. The second group believe that patients with carcinoma of the colon and rectum should be treated as are patients with carcinoma in other organs; that is, the growth should be excised by a wide margin and the area of lymphatic drainage removed with it so far as possible. It is quite evident that surgeons have never agreed upon what is "sufficiently thorough." Czerny in 1883 reported upon a combined abdomino-perineal operation for cancer of the rectum, but surgeons were not ready for so extensive an operation. In 1911, Miles, of London, after a careful study of cancer of the rectum, presented his combined abdomino-perineal operation for cancer of the rectum and gave excellent reasons for it. This brought forth a great many protests against such an extensive and mutilating operation and there were many statements similar to that of Doctor Paul, of Liverpool, who, in 1912, said: "Why should we undertake an extensive excision of the mesentery for the removal of glands which in all probability are not infected?" One English surgeon some years later said that so far as he knew, all his cases were alive and well after excision by the posterior route. It is only rarely that I

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have read a paper on the subject that one or more surgeons have not reported a case which had lived fourteen years after a local resection.

At the meeting of the American Surgical Association in 1929 in the discussion of the papers on cancer of the rectum, no one spoke of the value of the abdomino-perineal operation, but several reported a case alive five, ten, or more years after a local resection or what might be considered an inadequate operation. We were told at the same time that cancer of the rectum is an entirely different type of cancer, that the glandular distributions of the rectum are not like those of the breast or neck, and because the lymphatics intertwine between the bladder, uterus, and rectum, it is difficult to do a radical operation. Henri Hausmann about 1911 reported that of 112 patients dying of carcinoma of the colon the growth was still limited to the bowel in 50 per cent. of the cases. The Mayo Clinic report that in only 43 per cent. of the cases of cancer of the colon operated upon are metastases found in the glands.

What have all these statements to do with the proper treatment of cancer of the colon and rectum when it can be proved by statistics that not 10 per cent. of the cases seen are alive ten years later? The implication that a local or restricted operation gives as good results as an extensive operation because a surgeon here and there has had a patient live five years or more after a local or restricted operation is without foundation in fact. No group of cases in which a local operation has been done has been presented with all the facts necessary to determine the value of it. I am sure that many can match every case that has lived five years after a local operation with many cases that have died within two years because of local or inadequate operations. If the statement were accurate that there are no metastases outside the bowel in 50 per cent. of those coming to autopsy or that metastases are present in the glands in only 43 per cent. of those operated upon, we should be able to cure permanently between 50 per cent. and 100 per cent. of all cases seen, while as a matter of fact not 10 per cent. of the cases seen live ten years. Before statements about the value of any operation are made, we must know the type of growth and extent of local disease, the percentage of cases operated upon, the mortality, and the number of patients living in comfort three, five, or more years. If we are to believe that there is great value in a local resection or any operation less than a combined abdomino-perineal operation, then a large series of cases should now be reported in order that we may know what percentage can be operated upon and remain well for three, five, or more years.

If surgeons had the temerity, it is probable that many could report cases of carcinoma of the breast cured by local operation, but in carcinoma of the breast the extent of the operation is well established, while in carcinoma of the colon it is still legitimate to report a cure following a local operation as evidence that an extensive operation is not necessary. As to the network of lymphatics which intertwine between the uterus, bladder and rectum, it may be true that they do, but for practical purposes there is very good evidence

that these regions are not involved in many cases as shown by results in the more extensive operations. Do we not have the supra-clavicular glands and the lymphatics of the breast connecting with those between the ribs as well as other channels, as pointed out by Sir Sampson-Handley? Do we perform a local operation on cancer of the breast because of these inaccessible lymphatics? Is it not reasonable that we should treat cancer of the colon and rectum as we do cancer in other parts? Is it not time that we considered this subject from the point of view of the results obtained by the various operations? Is it reasonable that we should consider the value of an operation from results in two or three cases when they have been selected from 100 or 125 as has been done in many reports on the lesser operations? Should we not determine by statistics the operation which can be done with a reasonable mortality and which gives us the largest number of patients out of the total number seen, who have lived three or more years?

These reports of small series of cases treated by local or restricted operations without stating the percentage they are of the total number seen are discouraging to those trying to improve results and to operate upon a larger percentage of cases, and it makes it difficult to do any operation other than the limited ones reported because physicians and patients hear of them and will not submit to the more extensive and, I believe, better operations in most cases. I have met one man who is at least honest in the matter. He admits that he amputates the rectum by the posterior route because his mortality is lower than with the more extensive operations, and as his mortality is lower, it makes a better impression on the community even though the late results may not be so good.

We must admit, I think, until statistics prove otherwise, that the more extensive operations which include removal of the area of lymphatic drainage are the ones which should be undertaken when possible and that the experience of the surgeon and the condition of the patient are the only valid reasons for a lesser operation, except in an occasional carefully selected case when the type and extent of the disease are determined by an experienced surgeon.

Professor Grey Turner, in his address, stated that he had done fourteen local resections for cancer of the rectum. Four died within a year and nine months and five have been operated upon less than three years. While this seems to be quite a series, Professor Grey Turner, in a personal statement, told me that this list comprised between 2 per cent. and 3 per cent. of the total number of operations for cancer of the rectum, not a large enough percentage to make local resection a very valuable operation and yet one which has been advocated by several surgeons as the operation of choice.

We should not object to a surgeon selecting the operation which he is capable of performing, nor the operation best suited to the condition present or to the ability of the patient to withstand any particular operation. We should object to the statement not backed by statistics that a lesser operation is as good as or better than a more extensive one. It may be true that there

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is little use in attempting an extensive operation when the glands are involved, no series of cases has been presented to prove it, but if it is true, how are we to know when the glands are involved? In addition, many can report cases in which metastatic glands were found at operation and yet the patients have lived three, five, or more years.

It may be stated that at the time many of these statements in regard to carcinoma being a local disease were made, 25 per cent. or less of the patients seen were operated upon and not more than 25 per cent. lived three or more years. With the more extensive operations from 32 per cent. to 50 per cent. of the cases seen are operated upon, and of these over 60 per cent. live three or more years.

It is my hope that we can all agree upon the necessity of removing the growth with a wide margin at either side, and that the area of lymphatic drainage should be removed when possible. It may be admitted that a lesser operation must be performed many times and that such an operation is better than none. If we could agree upon the principles of the combined abdominoperineal operation of Miles for cancer of the rectum as coming nearest to the ideal at the present time, we would have accomplished much. It is quite easy to agree that an occasional case does not require such an extensive operation if the type of growth is Group I or II and if an experienced surgeon selects the cases for restricted operation. It is also true that certain patients are not sufficiently strong to withstand the ideal operation and many surgeons have not had sufficient experience to undertake it. We must, therefore, have operations for the patient who is below standard and for the surgeon of little experience.

In carcinoma of the colon we might assume that the ideal operation is excision of the growth with a wide margin and with all the mesentery of that portion of the bowel followed by an end-to-end suture, but here again we must have operations to meet the condition of the patient and the experience of the surgeon. We believe that the Mikulicz operation which is so strongly urged by some surgeons is frequently not applicable because it does not permit removal of a sufficient amount of bowel and mesentery. Given a patient in reasonably good condition, we believe that the only guide to the choice of operation should be the ability to remove a sufficient length of bowel and its mesentery. That is, in spite of the fact that the Mikulicz operation gives a much lower mortality, it should not be used unless a sufficiently wide margin of bowel and a large mass of mesentery can be removed.

There can be little doubt but that the controversy as to what is a "sufficiently thorough" operation for cancer of the rectum is kept up largely by those who object to the removal of the sphincter. Many of these surgeons are so opposed to it that they prefer to let the patient go on until a colostomy alone is necessary rather than make the patient comfortable or possibly cure him by removal of the growth and sphincter. Some of these surgeons, feeling that resection and preservation of the sphincter is so important, rarely find a case suitable for any operation if it is not suitable for resection.



In regard to the necessity for a colostomy in the great majority of cases, I believe that Turner, in his address to the American College of Surgeons, made a very significant statement when he said: "When efforts of the surgeon have been sufficiently thorough, the results have often been commensurate with the sacrifice which the patient has had to make." If this statement is true of malignant disease anywhere, it is true of carcinoma of the rectum. It may be a sacrifice to have a colostomy, but I thoroughly believe that the results are commensurate with the sacrifice. This of course assumes that the surgeon will teach the patient how to care for the colostomy, as almost the only patients who complain of their colostomies are those who have managed them according to their own ideas, that is, with cathartics. It is the duty of surgeons who operate upon carcinoma of the rectum to learn how to care for colostomies, for there is no mechanical method of controlling them in spite of all the operations that have been devised, and to learn from experience with patients their feelings in regard to colostomies, and not to allow sentimentality to keep them from doing a "sufficiently thorough" operation. A colostomy is necessary in the great majority of cases. The sphincter may be preserved in a small percentage only when the growth is quite early and the selection made by a man of great experience.

Most physicians and many surgeons obtain their experience in regard to colostomies from those patients in whom the growth has not been removed. Those who have had experience with colostomies after removal of the growth look upon them as a rule in an entirely different light. I may say that after seeing about 300 patients who have had a colostomy and the growth removed, I can state that I have not seen a patient who has not lived happily and contentedly. I have never known a patient to commit suicide after removal of the growth and a colostomy, but I have known of two or more who have committed suicide who have not been operated upon.

This is not a plea for the combined abdomino-perineal operation in every case, but a plea for a "sufficiently thorough" operation for every patient who can stand it. It is my belief that the saying that the smaller and the earlier the growth and the better the chances for a cure, the more extensive should the operation be, holds good today as well as formerly.

In dealing with carcinoma of the colon and rectum, I believe it is important for the surgeon to consider these cases from the point of view of making the patient comfortable rather than from the point of view of cure. If we operated only upon those patients who we think can be cured, there will be a large number of patients who could have been made comfortable for one, three, or more years who will not be operated upon. It is my opinion that comfort for one year is worth more than the discomfort of the operation.

While it is not possible to standardize the technic in resections of the colon, two fundamental principles might be agreed upon: (1) An adequate blood supply is a necessity, and (2) the line of sutures must be relieved of intra-intestinal pressure. We have, I believe, spent too much time on the consideration of the suture material, aseptic methods of anastomosis, and the



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advantages of an end-to-end suture over a lateral, or vice versa, while as a matter of fact the one essential always to an immediately successful operation is an adequate blood supply to the portions of the bowel to be sutured.

There are two problems in the blood supply to the portions of the bowel to be united. Jamieson and Dobson have shown that theoretically all portions of the colon should be supplied by any two of the main arterial branches to the colon through the vascular arches which connect the right, middle, and left colic arteries and the superior hæmorrhoidal artery. While this may be true if there are no anomalies, some of us have found that anomalies do occur and before any main artery is tied we must always be sure of a sufficient blood supply beyond. Jamieson and Dobson have also demonstrated that if the superior hæmorrhoidal artery is tied above the last branch to the sigmoidal arches, there need be no fear of a lack of blood supply to the lower sigmoid or upper rectum. This again may be true theoretically, but how often can we depend upon our accuracy in selecting the proper place to tie the superior hæmorrhoidal? It must be remembered that the life of the patient depends in most cases upon the accuracy of placing this tie, for necrosis will surely follow if the branch to the arches and the terminal portion of the superior hæmorrhoidal artery are tied. From experience with the combined abdomino-perineal amputation of the rectum I am convinced that in resections of the sigmoid there will not always be sufficient blood supply to the proximal end of the distal fragment from the middle hæmorrhoidal arteries even if these branches are not tied. It is probable, but not always certain, that the proximal bowel in resection of the sigmoid will receive sufficient blood supply if the inferior mesenteric artery is tied above the left colic branch. I have already had a case in which the inferior mesenteric was tied above the left colic in which there was necrosis of the whole upper sigmoid from the colostomy to the middle of the descending colon. Probably one of the most important factors in necrosis is injury to a perpendicular branch or branches close to the cut edge of the bowel. Injury to the first and second branches above the line of section will at times cause necrosis of one-half inch as was demonstrated by tying the perpendicular branches at the end of a colostomy. Another bit of evidence that the vessels are of importance is, I believe, shown by the less frequent leakage following a lateral anastomosis than after an end-to-end suture. The best suture material and the best suture known, the most carefully done anastomosis or an aseptic anastomosis are of no value if the blood supply is deficient.

The next most important fundamental principle in resections of the colon is the prevention of intra-intestinal pressure on the line of sutures. This has not been considered of sufficient importance to demand a sure remedy until quite recently, and even today many surgeons do not feel the necessity for carrying out this principle. It is true that many cases will do well with no particular provision for the prevention of pressure, but here again what we need are statistics to prove the value of this principle. We believe that the surest way to prevent pressure on the line of sutures in the left colon is to

make a colostomy a short distance above the line of suture, but we believe that a cæcostomy made by infolding the cæcum about a tube one-half to three-quarters of an inch in diameter is effective, never interferes with the field of operation, is sufficiently effective in emptying the bowel before operation and requires no secondary operation to close it.

There are other methods of preventing pressure upon the suture line, but they are not so effective as a safety valve as the cæcostomy or colostomy. Morphia has much value in keeping down violent peristalsis and it is the simplest method. Proper preparation of the bowels before operation as suggested by Rankin has its value, but it cannot be depended upon alone in all cases. In low resections with end-to-end anastomosis a three-quarter inch tube may be put in through the anus and through the anastomosis, but to be effective, the bowel must have been thoroughly cleansed before operation. It is true that many patients have lived after resections when nothing has been done to prevent intra-intestinal pressure, but is that a good reason for continuing a procedure which may bring disaster in any case?

As to other points in technic, they are of so little importance as compared to a proper blood supply and the prevention of intra-intestinal pressure that they will not be taken up. It may be said that so much stress has been laid upon the aseptic method of anastomosis by some authors that the two important factors in good results, blood supply and absence of pressure on the line of sutures, have been lost sight of.

As to drainage following suture, there will always be a controversy. It may be said, however, that fewer cases are drained than formerly.

## THE RELAXATION OF SCAR CONTRACTURES BY MEANS OF THE Z-, OR REVERSED Z-TYPE INCISION

STRESSING THE USE OF SCAR INFILTRATED TISSUES

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THE purpose of this paper is to call attention to a method by which flaps of scar tissue or of tissue considerably infiltrated with scar may be used in relaxing scar contractures. The utilization of such tissue for the relaxation of scar contraction is not generally understood although the Z-type incision by which it is accomplished is an old procedure.

It is a good plastic principle to remove all scar tissue before attempting any sort of reconstruction and this should be carried out whenever possible. However, there are many contracted scars where complete excision of the entire scar is impracticable on account of its extent and location. In these instances, unless skin grafting or flap shifting from a distant part is done, it is necessary to utilize scar or scar-infiltrated tissues, and often a great deal can be gained and much relief given by the proper use of such tissues.

In order to utilize flaps of scar-infiltrated tissue some manœuvre must be carried out which will relax the contracted band and break the line of scar tension. In suitable cases, this may be accomplished by the use of the Z, or reversed Z, or staggered Z, or S, or reversed S-incision as one may choose to call it.

The transposition of the flaps thus formed is made possible because there is always shortening of the tissues in the direction of the contraction and usually excess or fullness on both sides of the contracted band.

*History.*—A review of the literature was made by Dr. Herbert Wilgis and myself in order to determine, if possible, who first devised the Z-type incision and transposed the flaps thus made. As far as we can find, the earliest description of this incision with the transposition of the flaps thus made was by Denonvilliers in 1856, who apparently developed the procedure in steps. He used it successfully for the relief of ectropion of the outer third of the lower lid. This type of incision may have been used even before Denonvilliers, but we were unable to find an earlier report.

Szymanowski, in his book published in 1870, illustrated the use of a similar incision for the relief of a deviation of the angle of the mouth, so the method was well known to him. Piéchaud reported in 1896 the use of a modified Z-type incision for the restoration of the axilla and for the relief of scar contractures in other regions. He stressed the utilization of scar-infiltrated tissues and apparently made considerable use of the method. Berger and Bonset in 1904 used a Z-incision with the transposition of flaps for the restoration of an axilla which had been obliterated by scar contrac-

ture. Berry and Legg in 1912 employed the Z-incision for adjusting the vermillion border in a poorly repaired congenital cleft of the lip.

McCurdy in 1913, in 1917, and again in 1924 wrote on the Z-plastic method and emphasized the importance of implanting in the centre of the wounds flaps of normal skin and of shifting the burn scar to the ends of the field of operation. Morestin in 1914 described a method of relaxing a permanent flexion of the finger due to scar tissue by the use of a multiple Z-incision. An incision was made along the rim of the scar bridge dividing

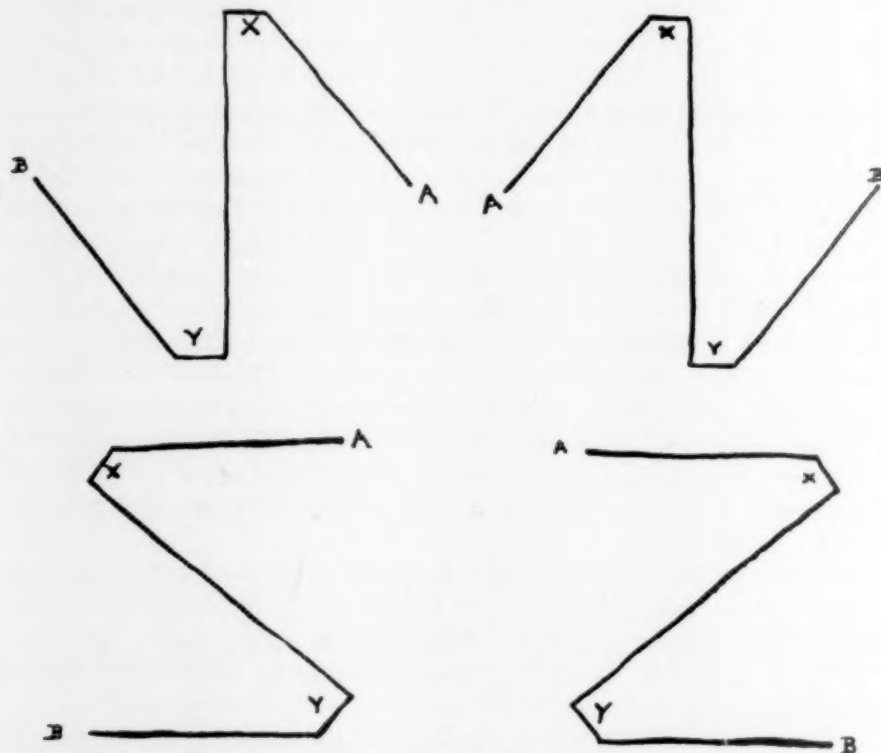


FIG. 1.—Illustrating the Z and reversed Z-type incision. In the diagrams the length of the corresponding lines making the incisions are the same, although they appear to vary considerably on account of the tilt of the figure. The longest line of the Z may be in any direction in which the scar contracture happens to be and the arms of the Z will necessarily change their direction to conform with this. In each of the diagrams after the blunt-pointed flaps outlined by the incisions are raised and transposed, the tip X is sutured into the angle formed at B, and the tip Y into that at A. The line AX being sutured to the BY.

it into two leaves, then from this central incision several lateral incisions were made forming a number of flaps. The finger was straightened and the flaps were drawn into the angles formed by the incisions made on the opposite side. In this way the scar bridge was released and the scar pull broken by a very irregular closure. This procedure was well illustrated diagrammatically by Rahm in 1923.

Frank S. Matthews in 1915 illustrated a modified Z-type incision for liberating a band of scar tissue which was quite similar to that used by Piéchaud, but was devised without knowledge of Piéchaud's work. Pieri in

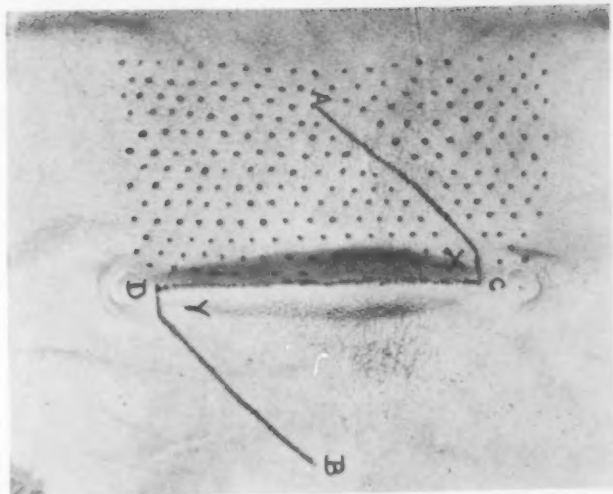


FIG. 2a.

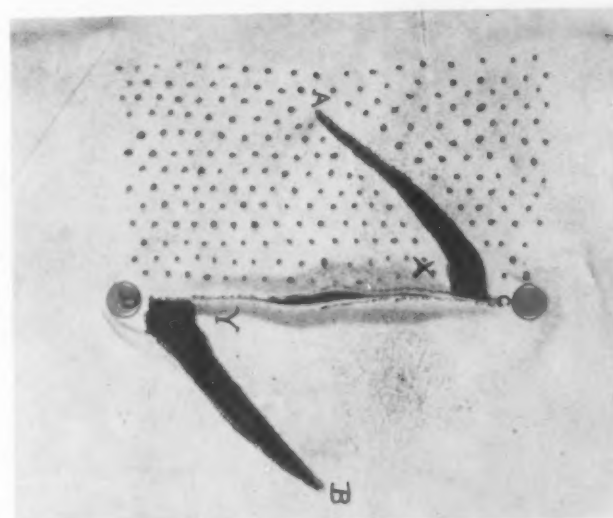


FIG. 2b.

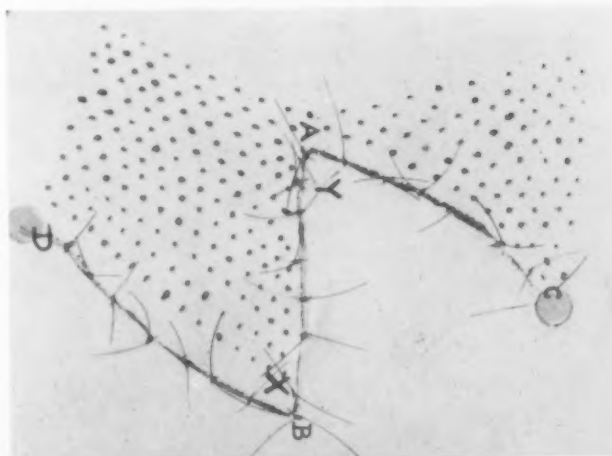


FIG. 2c.

FIG. 2a.—Demonstrating the Z-type incision which we have found most generally useful with the transposition of flaps. A piece of chamois skin was placed on a frame and the central portion was stretched singly between two thumb tacks to represent a scar bridge. Note the "scar bridge," CD which projects quite markedly. Along the centre of this bridge is the longest line of the Z; the arms of the Z, DB and AC, are marked out so that the tips of the flaps X and Y will be blunt. A portion of the skin has been dotted in order to show contrast after the flaps are transposed.

FIG. 2b.—Illustrating the shrinkage of the flaps after the Z-incision has been made. Note the gaps along the arms of the Z, which in a real scar are often much more marked, as naturally flaps X and Y lie completely separated and theoretically undercut. Note the incision has been made along the Z previously marked out ACDB and the scar pull would be greater than that in a piece of chamois skin.

FIG. 2c.—Illustrating the transposition of the flaps and breaking of the scar pull. Note the position of the flaps after transposition. The flap X made in the dotted portion of the skin being drawn into the defect made by raising the flap Y in the undotted portion and vice versa. The tip of the flap X being sutured to the point B and the tip of the flap Y being sutured to the point A. Note the approximation of the edges of the flaps with horsehair sutures, the edge AC of the dotted flap X being sutured to the edge BD of the undotted flap Y. The breaking of the "scar pull" and the relaxation of the bridge can be well seen. Note the increase in the distance between the thumb tacks as the relaxation obtained by the transposition of the flaps made it necessary to move them outward to the edges of the frame; also that the suture line is the staggered reverse of the original incision.



1919 illustrated the application of a modified Z-type incision with the transposition of scar flaps in deepening the commissures on badly mutilated hands. Davis illustrates the Z-type incision several times in his book on Plastic Surgery, published in 1919, and also in a paper on Arm-Chest Adhesions in 1924. He again demonstrated the use of this method on the face and neck in 1930 in the Section on Plastic Surgery in Dean Lewis' System of Surgery.

Steindler in 1923 illustrated his idea of Pieri's operation in relaxing a scar web on the thumb by the use of a modified Z-type incision and also showed an excellent illustration of the relaxing of a web between the thumb and forefinger by a Z-incision. Bosch Arana in 1925 wrote on the use of a modified Z-incision with the transposition of flaps in the phalangization of

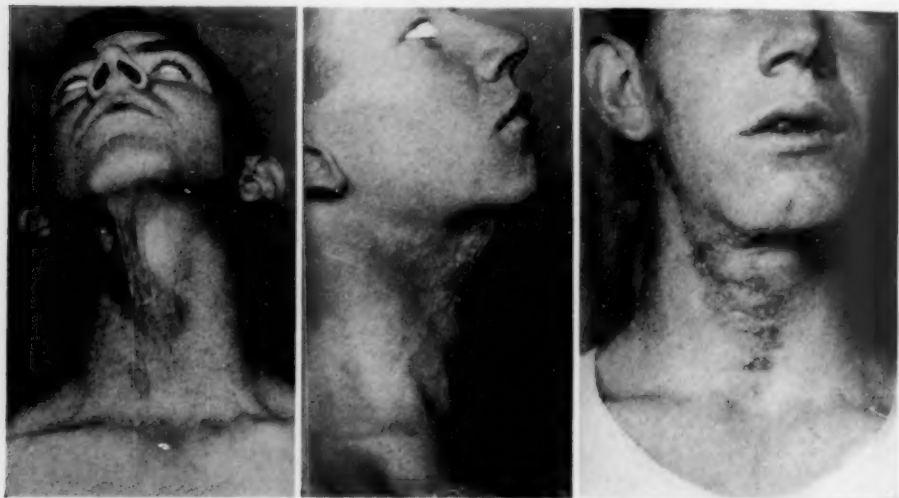


FIG. 3a.

FIG. 3b.

FIG. 3c.

Illustrating the use of the Z-type incision on the neck.

Figs. 3a. and 3b.—Old burn scar of neck. Note the width of the bridge and the extent of the scar. In this case a Z-shaped incision was made and the flaps were transposed.

FIG. 3c.—The result of this relaxation after twelve days can be seen. Note the complete relaxation of the scar bridge, the relief of tension and the satisfactory utilization of scar infiltrated flaps.

the first metacarpal. C. N. Dowd in 1927 published an article on the use of the Z-incision in the repair of cicatricial contractures of the neck. Babcock in 1928 illustrates nicely the use of the Z-type incision in what he describes as Pieri's operation for the relief of a web between the thumb and forefinger.

It is probable that the Z-type incision has been described in other articles which we have not mentioned, but there is no question but that it was used over seventy years ago, and that it has been frequently rediscovered and described as a new procedure.

*Technic.*—It is with those contractures which present a prominent bridge or web with which we most frequently have to deal, but the method is also very effective in dealing with the type of contracted scar whose contracted portion sinks into a groove and has a deep attachment instead of projecting as a bridge or web. This latter type of contracture is, of course, much less commonly found.

## RELAXATION OF SCAR CONTRACTURES

I usually choose a general anæsthetic, selected to suit the individual case, but if local anæsthesia is preferred for any reason, nerve block should be used, as infiltration of scar tissue is inadvisable on account of its precarious blood supply. The technic, which is quite simple, is as follows: Prepare the area to be relaxed by the method in which you have confidence. Mark out the proposed incision carefully with 5 per cent. brilliant green in alcohol on the contracted area, when the scar is under tension. The longest line of the Z is laid along the most prominent portion of the bridge or web, and the arms of the Z are marked out on opposite sides of the central line, making the pattern a Z or reversed Z depending on the condition of the surrounding tissues. The arms begin at each end of the central line on opposite sides and



FIG. 4a.



FIG. 4b.

Illustrating the use of the Z-type incision for the relief of scar contractures of the fingers.

FIG. 4a.—Shows the hand of a child with contraction of the index, middle and ring fingers following a severe rope burn. The middle finger was so badly burned that new tissue had to be supplied after straightening the finger, by means of a measured whole thickness graft. The ring and index fingers were not grafted but were relaxed by Z-type incisions.

FIG. 4b.—Result five months later. Note that the result following the Z-type incisions is as satisfactory as that following the whole thickness graft. All the fingers can be extended and function is fully restored.

are carried outward and downward, or outward and upward, as the case may be, as far as seems necessary, usually ending at about the level of the middle of the central line. The incisions are then made following the pattern, and the two flaps thus formed are undercut and mobilized and are transposed, the tip of one flap being sutured into the angle found at the outer end of the "arm" incision forming the other flap, and vice versa. The irregular wound is then closed with horsehair sutures, and is dressed with a single thickness of gauze impregnated with 3 per cent. xeroform ointment over which is placed a moist sterile seasponge applied under even pressure, and secured with adhesive plaster and a bandage. Finally the part is immobilized. When dealing with a grooved scar, the same procedure is carried

out except that the long line of the Z splits the groove lengthwise and the flaps are formed just as when a bridge is present.

*Comments.*—The treatment of burns and other extensive surface lesions which frequently result in contractures will not be considered except to say that every effort should be made to induce rapid healing with the part in proper position, as in this way excessive scar formation and subsequent contractures may be minimized. Some contractures may be avoided by very careful treatment of the original lesion, but my experience has been that contractures may and will occur in spite of every precaution. These con-



FIG. 5a.



FIG. 5b.

Illustrating the relaxation of a scar involving the axilla and trunk by the Z-type incision. FIG. 5a.—Burn scar of many years' duration. Several operations had been done previously. Note the condition in the axillary space and the dense scar extending from the axilla to the pelvic brim. FIG. 5b.—Result after two months. Note the release and smoothing out of the axilla, in spite of the fact that the tips of both flaps sloughed. Also note the relaxation of the entire scar on the trunk by the Z-incision which now allows much greater freedom of motion. These flaps were composed entirely of thick scar tissue, and it can be seen that they survived throughout.

tractures are found most frequently in the axilla; where the extremities join the trunk; around joints and on the neck and face.

As a general rule, it is advisable to delay operative work on contracted scars until nature, assisted by massage and passive motion, has had time to do all that she can. A few months will make a great deal of difference in the condition of the scar and of the surrounding tissues and by making haste slowly useless operations may be avoided, so that when we finally come to operate we will be able to see the scar as it eventually will be and can take steps to properly correct it.

This brings up the importance of the age of the patient with a scar contracture. During the growing period scar contracture, if not relieved, may materially interfere with the growth of the bony structure as well as of the

## RELAXATION OF SCAR CONTRACTURES

adjacent soft parts and may cause changes and deformities, which can never be completely remedied. However, if the contracture is relieved, say six months after healing is complete, which gives time for preliminary massage and other therapeutic measures, bone and soft part changes usually readjust themselves. In adults, on the other hand, while the question of interference with bone growth does not have to be considered, we must bear in mind the atrophy of disuse and in cases of long standing care must be taken not to cause fracture when manipulating a part, such as the arm, after relaxation. It has been my experience also that it is better not to operate on an adult



FIG. 6a.



FIG. 6b.

Illustrating the use of several Z-type incisions for the relief of a long scar contracture.

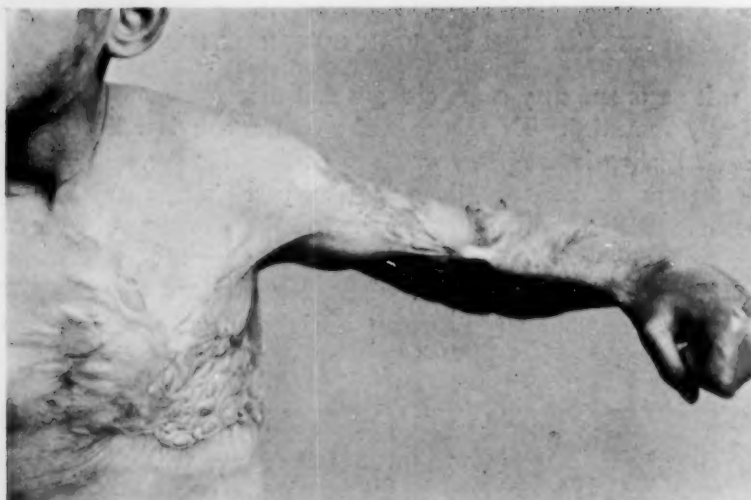
FIG. 6a.—Burn scar contracture of the thigh and leg. Duration, seventeen years. Note the thickened bridle in the popliteal space which has never healed. Also the extent of the scar on the thigh and leg. The patient is unable to fully extend the leg, and has the sensation of tightness and constant drawing. She tires easily and has considerable loss of function.

FIG. 6b.—Result two months later. The ulcerated portion of the scar in the popliteal space was excised and the edges were drawn together with temporary sutures. Then the Z was marked out, the incisions made and the flaps transposed. Three other Z-incisions were made in different portions of the scar and good relaxation was obtained. The patient can now walk without discomfort and has entirely lost the sensation of tightness on the back of the leg and thigh. It may be necessary subsequently to relax the depressed scar on the inner side of the thigh.

until six months have elapsed after healing is complete, in order to take advantage of improved conditions made possible by massage and stretching.

In many cases the flaps available are made up entirely of scar tissue. Only occasionally do we find a bridle or web with even comparatively normal skin running up to the contracted band, and in these instances the circulation of the flaps is naturally much more satisfactory. The ideal condition, of course, would be to break the scar pull with flaps of normal tissue.

If the scar bridle is fairly thin and soft, it is split its full length into two leaves, which are utilized as part of the flaps. If on the other hand the scar



Illustrating the use of the Z-type incision for the relief of scar contractures in the axilla, cubital space and at the wrist.

FIG. 7a.—Scar contracture following a burn. Note the involvement which extends from the chest to the hand. Some operative work had been done elsewhere before the patient came under my care.



FIG. 7b.—Result, after two weeks, of relaxation at the wrist and in the cubital space.



FIG. 7c.—The same arm after two years. During the interval further relaxation had been done on the axilla. Note the improvement in extension at the elbow and wrist.



## RELAXATION OF SCAR CONTRACTURES



FIG. 7d.

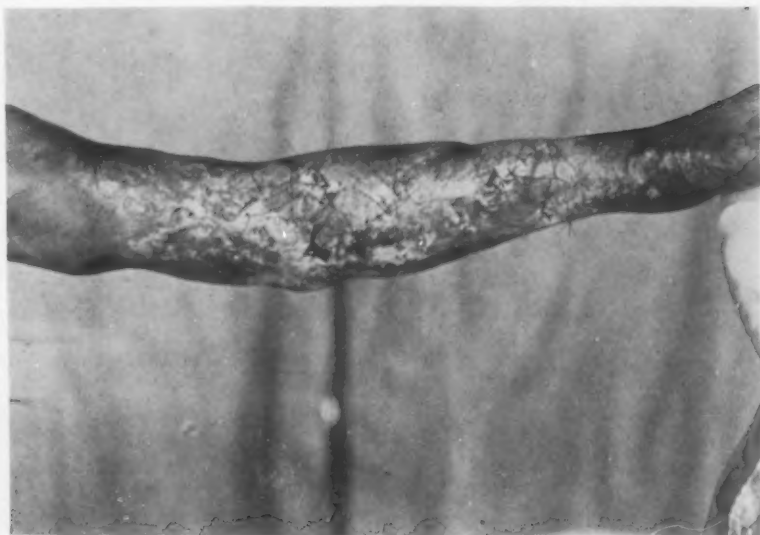


FIG. 7e.

FIGS. 7d. and 7e.—One week later the final contracture in the axilla was relaxed by a Z-incision which can be seen with the stitches in place. The wrist and cubital space were also relaxed by Z-type incisions made in scar partially relaxed by similar incisions done two years previously. Note that full extension is now possible and that an excellent axilla has been formed.



FIG. 8a.



FIG. 8b.

Illustrating the Z-type incision, used several times in the same area, for relaxing scar contraction. Figs. 8a. and 8b.—Extensive very thick burn scar of neck, chest and axilla. Note the extent and character of the scar.



FIG. 8c.—Result after eight months of the first use of the Z-type incision on neck and axilla. Note the difference in the character of the bridge and how much thinner and less dense it is. The Z-type incision was again used on the neck and in the axilla.

# RELAXATION OF SCAR CONTRACTURES



FIG. 8d.—Result of the second use of the Z-type incision after ten months. The major portion of the neck bridge and axillary web have been relaxed.



FIG. 8e.—The remaining contracture of neck and axilla relaxed by Z-incisions used for the third time in the same areas. Note the modified Z-closure with the stitches still in place.



FIG. 8f.



FIG. 8g.

FIGS. 8f. and 8g.—Result after one month. Note the restoration of the neck and axilla.

bridle is thick and hard and is unpromising for use, then an elongated ellipse of tissue including this portion is excised and the edges are brought together with a few temporary sutures. The Z or reversed Z is then marked out, the incisions are made and the flaps are raised and transposed in the usual way.

The lines marking out the prospective flaps may vary considerably in shape and direction according to the pull of the contracture and the type of the surrounding tissue, and in this way many modifications of the Z-incision may occur. In planning flaps care must be taken to utilize the best available tissue and for this reason the incision may be a Z or reversed Z depending on whether there is less infiltration with scar to the right or to the left of the line of contracture and above or below a transverse mark dividing this line. In other words, if the tissue is less infiltrated with scar in the upper left quadrant and in the lower right quadrant (facing the patient), then the Z is used and vice versa. The contraction pull of the scar on the two sides of a central bridle may be quite different and consequently after the flaps have been formed and undercut, they may be drawn entirely away from the anticipated position. In these instances, readjustments by properly placed secondary incisions may be necessary and must be carried out before the desired relaxation can be obtained and the wound closed.

In a wide scar bridle, relaxation may be secured in more than one place, or in more than one direction by the use of the Z-incisions. In long contractures, say from the buttock to the ankle, I have used three or four of these relaxations at one operation, before the contracture was completely relieved. This was possible as there was sufficient tissue between the selected areas to prevent interference with the circulation of the flaps already made and transposed.

Should scar bands be found deep in the tissues after raising the flaps, they should be either divided or better still removed, and all tension relieved before the flaps are transposed and sutured. The flaps should be handled with small sharp dural hooks to avoid bruising. The sutures should be of horse-hair threaded on fine half-curved needles and only enough should be put in to approximate the edges. All tension on the flap should be avoided.

The tips of the flaps should be made blunt instead of pointed, as when thus made they are much less liable to slough. Even if the tips of the flaps do slough, which sometimes happens when there is much scar, we often find that sufficient relaxation has been accomplished and that soon the defect left by the sloughing tips will be filled up and the scar will become smooth again. It is advisable to have the flap as thick as may be, including some subcutaneous fat if it is present, in order to conserve the circulation. Should the tips of the flaps become bluish after a few hours of the sponge pressure, it is advantageous to apply continuous compresses saturated with normal salt or boracic-acid solution.

I have used the Z-incision for the relief of tension in fairly broad tight scars with considerable success. In the relief of congenital webbing of the neck, the Z-incision with the transposition of flaps is the method of choice.

## RELAXATION OF SCAR CONTRACTURES

It is also most useful in deepening the commissures in incomplete syndactylism with a wide web.

When the Z-incision is used on the wrist, the flaps must necessarily be fairly short and it is better to relax at two different points rather than to attempt the formation of flaps which are too long. This may also be said of flaps about the fingers. The relaxation of a scar web, or of a congenital shortening of the web between the thumb and forefinger can often be easily relieved by a Z-incision with the transposition of flaps.

The Z-incision can be used for the relief of long contractures such as those in the axilla, and also very satisfactorily in short ones, such as we often find around the nose and ears. This gives an idea of the flexibility of the method.

In marked contractures of long standing with shortening of the underlying tissues, as much as possible should be gained at the first operation with the Z-type incision and subsequently the same procedure may be carried out in the same area after the deeper tissues have had time to stretch and soften. The character of the scar itself often changes materially, for the better, after relaxation.

The Z-type incision may also be used most advantageously in shifting the position of tissue which may be out of line. For example, where an eyebrow has been torn in an accident and two sections have healed on different levels so that one is considerably higher on the forehead than the other, by means of a properly placed Z-type incision with the transposition of flaps, the normal position can be restored quite satisfactorily.

## CONCLUSIONS

As we use the Z-type incision the scar is not removed but the contraction is relieved by the transposition of flaps which are usually composed of scar or scar-infiltrated tissue, in such a way as to break the line of scar pull. The suture line after transposition of the flaps is, in a general way, the reverse of the original incision. It is difficult to realize how much permanent relaxation can be secured by the use of scar-infiltrated tissue and this type of incision, until one is familiar with the procedure and its possibilities. The method has simplified the handling of many cases which would otherwise have had to undergo a much more extensive and serious operative procedure in order to obtain relief.

The Z-type incision has been of great use to me when dealing with contractures in all parts of the body. I have utilized it in a large series of cases and consider it one of the most generally useful manœuvres in my armamentarium.

## REFERENCES

- Arana, Bosch: Phalangization of the First Metacarpal. *Surg., Gyn. and Obst.*, vol. x1, p. 859, June, 1925.  
Babcock, W. W.: *A Text-book of Surgery*. W. B. Saunders Co., Phila., p. 1294, 1928.



# JOHN STAIGE DAVIS

- Berger, P., and Bonset, S.: Traitments de déformations consécutives aux cicatrices vicieuses de l'épaule. Chir. orthop., p. 180, Paris, 1904.
- Berry, J., and Legg, T. P.: Harelip and Cleft Palate. P. Blakiston's Son & Co., p. 148, Philadelphia, 1912.
- Davis, J. S.: Plastic Surgery. P. Blakiston's Son & Co., pp. 275, 372, 546, 547, 553, 632, 633, Phila., 1919; Arm-Chest Adhesions. Arch. Surg., vol. viii, pp. 1-23, January, 1924; Contracted Scars. Section on Plastic Surgery, Practice of Surgery. Dean Lewis, vol. v, p. 108, Ch. 8, 1930.
- Denonvilliers: Blépharoplastie. Bull. Soc. de Chir. de Paris, vol. vii, p. 243, 1856-1857.
- Dowd, C. N.: Some Details in the Repair of Cicatricial Contractures of the Neck. Surg., Gyn. and Obst., vol. xlv, p. 395, March, 1927.
- Matthews, F. S.: Johnson Operative Therapeutics, vol. iii, p. 380, 1915.
- McCurdy, S. L.: Z-Plastic Surgery. Surg., Gyn. and Obst., vol. xvi, p. 209, February, 1913; Z-Plastic Surgery. Intern. J. Surg., vol. xxx, p. 389, December, 1917; Correction of Burn Scar Deformity by the Z-Plastic Method. J. Bone and Joint Surg., vol. vi, No. 3, p. 683, July, 1924.
- Morestin, H.: De la correction des flexions permanentes des doigts, etc. Revue de Chir., vol. L, p. 1, July, 1914.
- Piéchaud, T.: Deux observations de symphyse des membres à la suite de brûlures étendues. Rev. d'orthop., vol. vii, p. 81, March, 1896.
- Pieri, G.: Ricostruzione del pollice dal moncone della folange basale, La Chir. degli organi di movimento, vol. iii, p. 325, 1919.
- Rahm, H.: Die Morestin'sche Plastik bei Fingerkontrakturen, Beitr. z. Klin. Chir., vol. cxxvii, No. 1, p. 214, 1922.
- Steindler, A.: Reconstructive Surgery of the Upper Extremity. D. Appleton & Co., p. 119, New York, 1923.
- Szymanowski, J.: Handbuch der Operativen Chirurgie, pp. 262-278, 1870.

## GENERAL SURGICAL CONTRIBUTIONS

NOT PRESENTED BEFORE THE AMERICAN SURGICAL ASSOCIATION

### AVERTIN ANÆSTHESIA\*

FROM THE ANÆSTHETIST'S STANDPOINT: A RÉSUMÉ OF EIGHTEEN MONTHS' EXPERIENCE

BY JOSEPH KREISELMAN, M.D.

OF WASHINGTON, D. C.

PRESENT-DAY surgery requires a variety of anæsthetic agents. The desirability of general anæsthesia by rectal administration in certain surgical procedures and in the presence of certain types of pathology is quite evident.

In 1926, Willstätter and Duisberg were successful in the development of the drug tribromomethylalcohol, also known as avertin.

*Description.*—Avertin is a white crystalline substance, easily soluble in water at 40° up to 3½ per cent. Its molecule is very labile, breaking down when heated above 45° with the formation of hydrobromic acid and dibromacetaldehyde. The latter substance is injurious to the intestines.

*Administration.*—The evening before operation a cleansing enema is given. Special measures to empty the intestines on the day of operation are to be avoided, as the fluid which may remain in the bowel may retard absorption. Before the operation morphine is given as in preparation for general anæsthesia. The measured amount of avertin is dissolved in a sufficient quantity of distilled water at 35° to 40° to make a 2½ or 3 per cent. solution. After being tested with a few drops of congo red (add 5 cubic centimetres of the solution to a few drops of congo red, resulting color should be a clear orange-red) the solution is injected into the rectum one-half hour before operation.

The tube is removed and the patient is allowed to remain undisturbed until asleep. If a minor operation is to be performed, no other anæsthetic is given unless it is found necessary. If the operation is to be a major one, supplemental anæsthesia is now given.

*Dosage.*—Our dosage has varied from 60 milligrams to 120 milligrams per kilogram of body weight. One hundred milligrams per kilogram should not often be exceeded. In estimating the dosage, the weight of the individual is taken as a basic index, and the dosage is then varied according to the experience of the anæsthetist. A mechanical measuring of the dosage according to the body weight should not be done. It has been found that children and young adults require larger doses than the other types. The obese, debilitated, and aged require less. Those with impaired elimination require much less than the average.

No effort is made to produce complete anæsthesia with avertin alone. It is

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\*Read before the Philadelphia Academy of Surgery, May 4, 1931.

used as a basis on which deeper anaesthesia may be produced with the gases or ether. This has been called basal anaesthesia.

*Absorption and Elimination.*—Avertin is absorbed by the intestinal mucosa more rapidly than is the water in which it is dissolved. The absorption is fairly rapid, 80 per cent. in the first twenty minutes and 95 per cent. within the first two hours.

If unduly deep anaesthesia occurs within the first twenty minutes, the rectum should be evacuated by washing with water. This not only rids the bowel of the avertin solution, but also dilutes it and delays absorption of that which remains.

Detoxification occurs by combining with glycuronic acid in the liver and it is eliminated in this manner almost entirely by the kidneys.

Adrenalin and salt solutions are effective in combating marked falls in blood pressure. Carbon-dioxide-oxygen mixtures may be used in stimulating respiration.

*Action.*—There is apparently no local action. Sleep comes on gradually without excitement in from ten to thirty minutes. There is no recollection of induction. The ocular reflexes disappear, and with the average dosage the pupils are contracted and react to light.

*Duration of Anaesthesia.*—In most cases the patient sleeps soundly for approximately two hours after induction. For the next three to four hours the sleep is light and intermittent. Nursing care is important at this time in maintaining a clear airway.

The respiratory rate is increased and the depth decreased.

The pulse rate approaches the normal. There is usually a fall in the blood pressure. There have been four cases with marked falls in blood pressure without apparent shock.

It appears that avertin acts in a different manner upon the brain than the anaesthetics in common use. In cases in which major surgery was performed and in which no general anaesthesia was necessary, it appeared that impulses reached the brain. This was made evident by perspiration, with change of temperature of the skin, an increase in the pulse rate, and a fall in blood pressure.

However, in these cases, there was also satisfactory relaxation.

In minor procedures, these symptoms were not apparent. Because of these untoward effects, it is a better procedure to combine avertin with ethylene-oxygen or nitrous-oxygen, or ether. These combinations afford satisfactory anaesthesias of moderate depth.

No adaptive response is excited by the anaesthetic. There is a minimum of disturbance to the sensory mechanism and mentality, hence there is a minimum of shock.

It is impossible to estimate the amount of damage done by the psychic shock produced in some patients, particularly in children, immediately preceding and during induction of anaesthesia.

Anaesthesia in pediatric surgery has always been difficult. It has been

## AVERTIN ANÆSTHESIA

almost impossible to do major surgery with gas. The pre-operative preparation is unsatisfactory. Because of the variable and very often untoward results with morphine, it has become routine not to use it in small children.

We then have the picture of a small child either poorly or entirely unprepared for operation. Good preparation is even more essential here than it is in the adult. The element of fear is great when the child is forcibly held and made to take an anæsthetic.

Avertin has filled the great void in pediatric surgery. A child may now be given a small enema in bed and in a few minutes he has fallen asleep without excitement and without being aware of the impending operation. The patient is returned to bed, where most of the day is lost in sleep. The post-operative convalescence is not attended by the usual unpleasant post-anæsthetic upsets.

*Utility.*—Avertin is particularly suitable in operations upon the larynx, cauterization of the tongue, intra-nasal operations, in moving patients with multiple fractures, in thyroid surgery, where a prolonged period of post-anæsthetic rest is wanted, when it is necessary to operate during acute alcoholism, in children, and when a general anæsthetic is distasteful to the patient.

*Contra-indications.*—1. Diseases of the liver and kidneys. 2. Advanced tuberculosis. 3. Extreme cachexia. 4. Acidosis. 5. Use with care when the elimination is delayed and in dehydrated and debilitated elderly patients, and in the obese. 6. Ulcerative diseases of rectum or colon.

### SUMMARY

The early reports in the German literature show many cases of intestinal irritation. There were many asphyxias and several deaths. The dosage was too high, the solutions were overheated, and there were no trained anæsthetists to evaluate the dosage and attend the patients.

We have used avertin in 1,500 cases. The dosage has been conservative, no effort being made to produce complete anæsthesia with avertin alone, this being deemed an unwise and dangerous procedure. There have been no unpleasant complications. The method of induction spares the patient some pre-operative apprehension. It requires an experienced anæsthetist to control the superimposed anæsthesia. More time is required. Accuracy in preparation of the solution is essential. It is not a routine procedure. The nursing care is an important factor (clear airway).

It is felt that with the anæsthetic agents now at hand, avertin has a definite place.

## AVERTIN ANÆSTHESIA\*

FROM THE SURGICAL STANDPOINT: A RÉSUMÉ OF EIGHTEEN MONTHS' EXPERIENCE

BY CHARLES S. WHITE, M.D.

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THE evolution of the administration of ether, from the paper cone and simple can, to the present day battery of tanks and valves, has taken place in a comparatively few years. The search for the ideal and universal anæsthetic, like the brook, goes on, and has brought to light several new and valuable agents, each with some particular virtue and some particular sin.

In the following recitation of our personal experience with avertin, we shall not enter into a discussion of the relative merits of the various anæsthetic agents, as it would open a contraversial subject. Each surgeon regards his favorite anæsthetic very much in the same way that the indulgent parent regards his child, and no good could possibly be accomplished by a comparative analysis.

Our experience with avertin began in August, 1929. Our first patient was a muscular negro who was given the German dose, that is, the dose recommended in the German Clinics in 1927 and 1928. The promptness with which the patient went to sleep, and the depth of anæsthesia which followed, convinced us that avertin at least had possibilities.

We secured the help of two veterinarians and at their hospital had them do a few operations and readily found the surgical and lethal dose of the drug in dogs. From that time we felt that we had a fair estimate of the maximum dose and it was not long before we had a working formula which we still use, although it is not as accurate as we would desire. We have used avertin in more than one thousand cases and still continue to use it routinely.

Doctor Kreiselman has discussed avertin from the anæsthetist's standpoint, and we shall stress the clinical manifestations, rather than the administration and physiologic actions. The induction has been uniformly quiet, and nothing approaching a mania has been seen in a single case. Occasionally, the patient becomes loquacious and hilarious but never combative; and sleep follows within ten minutes.

In a few medical students one of our friends timed them for loss of memory after the introduction of avertin, and it was found that consciousness was lost after three minutes, although several of them spoke intelligently for two or three minutes longer. It may be a peculiar trait of medical students to be intelligent when they are apparently unconscious. My experience has been just the opposite.

In about 2 per cent. of the cases, the patients reacted excitedly, just as we

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\*Read before the Philadelphia Academy of Surgery, May 4, 1931.



## AVERTIN ANÆSTHESIA

occasionally meet after ether, but this is decidedly the exception to the rule. In our total number of cases, restraint has been necessary only two or three times. The patient becomes coherent in from two to three hours after administration of the anæsthetic, then falls into a semi-conscious state for an hour or two longer, during which time he will be responsive to ordinary conversation. From this period his convalescence is not noteworthy.

In no case do we depend exclusively upon avertin, but a supplemental anæsthetic is always employed. The induction of the anæsthetic state is prompt and comfortable and, in this respect, it is not approached by any other agent with which we are familiar.

The relaxation during avertin anæsthesia, with the dosage we employ, is often sufficient for minor manipulations, or operations, but not sufficient to proceed with an abdominal exploration, and for that reason we use a supplemental anæsthesia—ethylene, nitrous oxide, or novocaine. In a difficult case, it may be necessary to add a small amount of ether at the time that the greatest possible relaxation is necessary, but this is not done routinely. With the larger dose of avertin, complete relaxation can be secured, but we believe that the patient takes an unnecessary risk, and the practice is to be discouraged.

We have not had circulatory or respiratory failure in any case during an operation, nor have we lost a case subsequent to operation, from any cause, that could be attributed to the anæsthetic. On several occasions, the respiration became very shallow, during the administration of ethylene or nitrous oxide, but the use of carbon dioxide and oxygen allowed us to proceed in every instance. In brief, we have had no accidents, not even an explosion of ethylene.

We have had our post-operative trials and tribulations and have worried about vomiting and distention, just as we have always done and just as we always expect to do. It is a mistake, we believe, to attribute the vomiting after operations to the anæsthetic, particularly after abdominal operations. No one doubts but that any anæsthetic, improperly administered, may be the source of vomiting, but in many instances, particularly in persistent and protracted vomiting, we should look for obstruction, peritonitis, acidosis, or alkalosis. We feel that the anæsthetic is stressed unduly as the cause of vomiting. However we found that 22 per cent. of our cases had post-operative nausea or vomiting and this is less than one-half the percentage we found with ether.

We have not observed that distention was any more or any less after avertin than any other general anæsthetic, and the same statement holds good regarding retention of urine. Here, too, we believe that the anæsthetic has a good alibi.

The remote complications are always of much interest and importance, particularly in reference to the lungs and kidneys.

Naturally, we avoid any general anæsthetic in any known acute pulmonary disease, but the unfortunate fact remains that some subacute condition may be present and not detected prior to the operation. With a better understanding of lung complications, for which we are largely indebted to Dr. Walter

E. Lee, the so-called ether pneumonia has been replaced by atelectasis, or collapse, and just what part the anæsthetic plays in this, we confess our ignorance. Our experience leads us to say that collapse of the lung has been more frequent after spinal anæsthesia, than any other, but our cases have been too meagre to be of any real value in estimating the relative frequency. We have had post-operative elevation of temperature, cough and expectoration of various degrees of severity after avertin anæsthesia. These cases were not X-rayed before and after operation and, in most instances, the diagnoses were not conclusive. The röntgenologist and internist have not completely agreed and it is impossible to state the relative frequency of lung complications following avertin. One thing is certain, the incidence has not increased. Some of the cases were a concern for merely a day, and four were quite ill, but no mortality followed from that cause. We feel that this question is still debatable and considerable research is necessary before the relation of the anæsthetic to pulmonary collapse can be rationally discussed.

We have not hesitated to use avertin in cases of chronic pulmonary tuberculosis and have seen no ill effects.

As avertin is not a renal irritant, we should expect no untoward effects after its use in a patient with normal kidneys, as we estimate normal kidneys by urinalyses. Our experience bears this out. We have not found any serious aggravation of a mild nephritis after its use, if we believe that a trace of albumin and a few casts are indicative of kidney disease. With a seriously impaired renal function we question the propriety of any general anæsthetic.

As the liver bears the brunt of avertin disintegration, it is the organ that should suffer most following the administration of this anæsthetic. This is probably true, but has not been brought home to us by actual experience. The liver will meet the demands of the body when the entire organ is almost replaced by a neoplasm. It seems endowed with a superhuman metabolic mechanism. It stands abuse almost as well as the stomach, and it is for that reason, perhaps, that we have failed to notice toxicity of hepatic origin after the use of avertin. In one instance we put it to a test. A patient with advanced carcinoma of the liver had a strangulated hæmorrhoid and we elected to relieve him under avertin anæsthesia. His expectancy of life was very brief and we are sure that both the patient and the family would have been grateful for an earlier end. The anæsthetic put him to sleep promptly and the operation was satisfactorily done. The atypical aftermath was the delirium, which lasted three days.

There are said to be two contra-indications to the use of avertin. Serious impairment of liver function and ulceration of the rectum. It is apparent why it should not be used in a case of damaged liver, and it is not used in an ulcerated bowel, because it will not be absorbed promptly, even if it is retained. These contra-indications should be accepted until confirmed or disproved by further use of the drug.

## AVERTIN ANÆSTHESIA

### SUMMARY

Avertin offers a safe, comfortable, and speedy approach to the full state of anæsthesia, provided the dose does not exceed 100 milligrams per kilo. of body weight, and is given by a competent anæsthetist. We desire to particularly stress first, the smaller dosage, as compared with the German formula; secondly, an anæsthetist must have charge of the anæsthetic. Supplemental anæsthesia, with novocaine, ethylene, nitrous oxide, or even ether is recommended. We know that many will offer the objection that two anæsthetic agents complicate the administration. We believe that the comfort the patient enjoys and the fear from which he is relieved, are well worth the additional effort and time on the part of the anæsthetist. No better proof is necessary than the statements of the patients who have had both types of anæsthesia. We even have anæsthetists in Washington who would take avertin by choice, and no greater thing could be said of any anæsthetic. We believe the professional anæsthetist is just as essential to the perfect operation as the surgeon's assistant, the pathologist, or any other member of the hospital staff.

The contra-indications to the use of avertin at the present time are serious impairment of liver function and ulceration of the rectum.

Doubtless some may ask themselves: Why a new anæsthetic, with the number of anæsthetic agents in use today? We would answer that question much as Faraday answered a similar question many years ago. After he had read, before a distinguished audience, a paper on electro-magnetism, someone asked him, "What is the use of all these new ideas?" Faraday replied: "What is the use of a new-born babe?"

THE RESULTS OF AVERTIN BASIS ANÆSTHESIAS, WITH ETHER,  
NITROUS OXYGEN AND ETHYLENE—BASED ON  
CLINICAL AND METABOLIC STUDIES—REPORT  
OF 700 CASES

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THE standard for any kind of anæsthesia used in surgery should provide, as far as possible, for the safe exclusion of pain and psychic disturbance of the patient in order to make the operation a success.

The following paper has to deal with 700 cases of avertin anæsthesias with the idea of ascertaining how far we are able to fulfill these postulations.

Out of 1,750 operations in one year, 700 operations were carried out under avertin anæsthesia. Hence, it is clear that not all cases are adaptable to avertin and that the principal indication for every anæsthesia has to be made for each patient individually. In other words, the surgeon has to decide for every single case which form of anæsthesia is best adapted to each patient. Therefore, it is necessary to bear in mind the general condition of the patient, heart and lungs and state of shock, *etc.* If the circulatory system is weak, then avertin anæsthesia is contra-indicated. Furthermore, in our hospital, complete avertin anæsthesia without supplementary measures is not used. By the results and experiences of the German authors there is shown that doses of avertin, needed for a complete anæsthesia without supplement, are too large and too toxic, so that it is not advisable to force a complete avertin narcosis (Rehn and Killian<sup>27</sup>). Such a complete narcosis with the toxic, non-controllable avertin does not correspond with the biologic laws of the organism, particularly not with those of the diseased organism.

Here, therefore, we are dealing only with the avertin "basis narcosis" (Straub<sup>30</sup>) and its combination with ether, nitrous oxygen ( $N_2O$ ) and ethylene ( $C_2H_4$ ), the latter two being combined with oxygen.

First, there is a brief note necessary as to the principal fundamentals of the supplements used in order to compare their effect and biologic reaction in combination with avertin.

*Ether.*—Ether acts as a stimulant to blood-pressure, especially at the beginning of its administration, while avertin has a tendency to decrease the pressure. Blalock and Franken<sup>12</sup> have called attention to the increased heart effort due to a specific heart reaction caused by the ether. By increasing or decreasing the ether blood concentration, one can readily control and regulate the respiration, and hereby accomplish an individual deep or light anæsthesia. Anschuetz<sup>3</sup> states that there is a "favorable influence of ether on blood-pressure and respiration, when avertin is combined with small amounts of ether," and it doubtless compensates in part for the severe drop of blood-pressure, which is as a rule the case after using avertin.

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*Nitrous Oxide with Oxygen* ( $\text{N}_2\text{O} + \text{O}_2$ ).—The circulatory system is not unfavorably influenced, the blood-pressure does not drop and there is no inconvenience to the respiratory centre.  $\text{N}_2\text{O}$  does not influence the metabolism to any greater extent; for instance, there is no increase in lactic-acid content in the blood, or no regular prolonged increase of blood-sugar content. The disadvantage of a relatively light anæsthesia when used alone becomes an advantage in the combination with the strong narcotic effect of avertin, as it is compensated in so far as small doses of avertin are used (Domanig,<sup>10</sup> Floerchen<sup>11</sup>).

*Ethylene* ( $\text{C}_2\text{H}_4$ ).—No disadvantage has been found in the use of nitrous oxide as well as ethylene on the circulatory or respiratory system. There has been noted during the course of ethylene administration an elevation in blood-pressure, which is particularly desirable in view of the undesirable effect of avertin. No severe hyperglycæmia, no diminishing of the  $\text{CO}_2$  combining power, or only a small decrease of alkali reserve is found after ethylene, its narcotic effect being stronger than that of nitrous oxide and its very quick deprivation of the lungs corresponding to the sudden awakening of the patient. Luckhardt and Carter<sup>12</sup> (1923) and Luckhardt and Dean Lewis<sup>13</sup> (1923) employed ethylene for the first time as an anæsthetic on humans. The latter authors note 700 ethylene anæsthesias on an experimental basis and favorable clinical results. According to them a concentration of 80 to 90 per cent., ethylene to 20 to 10 per cent. oxygen is necessary for a complete ethylene anæsthesia. Dean Lewis has resected the stomach, using ethylene for the anæsthesia without any complications (J. A. M. A., vol. lxxxi, p. 1854, 1923). The above-mentioned concentrations are given for a complete ethylene anæsthesia. In our experiments with numerous combinations of avertin ethylene narcosis we find that these smaller concentrations often give good results. A certain advantage of ethylene is the better peristalsis of bowels in the post-operative condition, so that the post-operative pains, as well as the distention by gas, and also the danger of post-operative ileus is diminished (Dean Lewis). Contrary to ether there is no increased mucous secretion, so bronchitis and bronchopneumonia are rare.

*Disadvantages of Ethylene*.—(1) Bad odor, which, nevertheless, is noticed only a very short time before the quick narcotic effect. (2) Slight increased bleeding from the wound. (3) The danger of explosion, which can be avoided or diminished by pure ethylene free from carbon-monoxide, making it necessary to avoid the dangers of this highly inflammable gas via fulguration, open lights, lighting cigarettes, etc. We may perhaps state that it would be inadvisable to put the ethylene tank near the operating table, but as near the operating room as possible, keeping in mind that this necessitates a longer length of tube from the machine to the patient, which is a disadvantage, but acts as a safeguard as far as an explosion is concerned.

*Technic of Avertin Anæsthesia*.—Pre-operative treatment. Morphine 12 milligrams. Atropin 0.6 milligram. The avertin solution is prepared every morning, separately for each case and prior to each operation. The average dose is usually 90 milligrams per kilo. Smaller doses of 80 to 85 milligrams per kilo, particularly for smaller operations and for weak, cachectic patients, are often used. In cases with a poor general condition and in children, even smaller doses of 60 to 70 milligrams per kilo are used; in strong men 90 to 95 milligrams per kilo is the limit. A 3 per cent. avertin solution is used and it is necessary to have a regular control of avertin solution by Congo red.

According to our clinical experiences and to the proposals of Rehn and Killian, etc., only avertin basis narcosis should be carried out as a rule. With the use of this anæsthesia, there is an apparent deep sleep with relative relaxation but accompanied by a positive feeling of pain. Ether, nitrous



oxide or ethylene is used as a supplement before operation. If, in a single case, the supplement with  $N_2O$  is not sufficient, then one can change or combine  $N_2O$  with ether, which is easily done by the use of the Foregger or McKesson machine. In such a way one can control and steer the avertin basis narcosis with a larger or smaller amount of ether or gas supplement. This clinical statement is founded on the pharmacologic investigation of Straub,<sup>30</sup> Lendle<sup>18</sup> and also on the clinical reports of White,<sup>33</sup> Parsons,<sup>25</sup> Lundy,<sup>24</sup> Guttman,<sup>13</sup> Speidel<sup>29</sup> and others.

In 700 such cases avertin basis narcosis was employed and combined with ether or gas without fatality and with very satisfactory results. There is a definite blood-pressure effect with avertin (an average drop of 30 to 40 milligrams mercury). Immediately after the ether effect and likewise after gas, a certain rise of blood-pressure is always the case. The blood-pressure curve shows better results after these mixed anæsthesias than after a complete avertin anæsthesia. In some cases, ephedrine was given with the avertin enema to prevent the drop of blood-pressure, as ephedrine is absorbed by the mucous membrane; with and sometimes without results. We should, nevertheless, bear in mind that after other anæsthesia methods, a drop of blood-pressure is known to occur, for instance, after spinal anæsthesia (Pitkin) and after caudal anæsthesia (Widenhorn<sup>34</sup>).

Then, too, we must not neglect the fact that independent of the anæsthesia, a decrease of blood-pressure may result from the operation itself (pulling the peritoneum or the splanchnic nerve or the pedicle of the kidney, *etc.*).

The pulse shows generally a reasonable elevation and remains at this level and rises on the average of 100 to 110 pulsations a minute. Ether and gas have an increasing influence.

The respiration during this combined method is essentially more favorable than after complete anæsthesia. The statement of Puckner's<sup>26</sup>: "Avertin depresses the respiratory centre, lessening both frequency and volume," is correct for the complete avertin anæsthesia. In the majority of our cases, our protocols of the frequency and breathing per minute are the same in the beginning, during and at the end of the anæsthesia, usually 20 to 22 respirations per minute.

During each of the 700 anæsthesias the blood-pressure, pulse, and respiration were measured at intervals of five minutes.

The amount of the supplementary anæsthetic depends on the following: (1) On the amount of the single dose (milligram avertin per kilo). (2) On the amount of the whole dose (cubic centimetre per patient). (3) On the type of operation. (4) On the time of operation. (5) On the individuality of the patient, as every patient requires an individual amount of avertin as well as of ether and gas.

Furthermore, the post-operative sleeping time after these anæsthesias was studied. One can differentiate between a first and a second sleeping time. The first one is counted until the patient first awakes, when the patient first reacts, responds and is able to speak. The second sleeping time includes

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the secondary phase of relaxation, which is incomparable to the deep sleep noted after complete avertin anæsthesia. After small doses of avertin anæsthesia the first sleeping time is remarkably short; often the patient awakes immediately after operation. If  $N_2O$  or  $C_2H_4$  is used with avertin, the short period of the first and second sleeping time is apparent.

The best adaptations for the use of avertin and ether are: laparotomies, resections of intestines, cholecystectomies, exophthalmic goitre, strong persons, men rather than women.

The best uses for avertin and gas are thoracic operations, the extremities, breast operations, anæmic and cachectic patients, women rather than men, age rather than youth.

Besides these clinical investigations we have carried out some metabolic studies and would like to give a few examples. With numerous patients the  $CO_2$  combining power and blood sugar at certain intervals were determined, in order to learn how great and how lasting was the effect of the anæsthesia. The alkali reserve ( $CO_2$  combining power) was determined after the method of Van Slyke, the blood sugar after Benedict. We know the very important influence of anæsthetics on these factors alone. Crile and Menten<sup>9</sup> (1915) found in dogs and rabbits an increase of PH-concentration after ether chloroform and nitrous oxygen. Caldwell and Cleveland<sup>7</sup> and Austin<sup>5</sup> found a decrease of alkali reserve after ether. Carter<sup>8</sup> and Morris discuss the decrease of plasma bicarbonate in dogs after ether. Atkinson and Ets,<sup>4</sup> as well as Van Slyke, Austin, and Cullen<sup>32</sup> have noted the decrease of  $CO_2$ -combining power of the blood, similarly reported but differently explained by Henderson and Haggard<sup>14</sup> (1918).

In regard to these changes, after complete avertin anæsthesia as studied by Achelis,<sup>1</sup> Wymer<sup>35</sup> and by Brugger, Wesley Burne and Dreyer<sup>6</sup> (McGill University) the latter authors have reported their experiment on dogs, and I would like to report my investigations on humans, since these results after avertin basis anæsthesia combined with small doses of ether or with  $N_2O$  or  $C_2H_4$  are not known.

$CO_2$  combining power and blood sugar was determined before, immediately after operation, and eight and twenty-four hours after operation to ascertain the intensity and duration of the influence of this particular anæsthesia on the metabolism of the body. In order to give the exact data concerning the quantity of avertin and ether, the type and time of operation, the table of measurements is included here.

The following was observed: After avertin and ether, the  $CO_2$  combining power does not drop so low as it does after complete avertin narcosis. It drops slightly, improves after eight hours, and remains at the normal rate in twenty-four hours.

After avertin and ether the blood sugar, as after many anæsthesias, increases; nevertheless, it does not rise so highly as it does after complete avertin anæsthesia (see table). The normal rate usually occurs after eight hours, and regularly after twenty-four hours.

## HANS WIDENHORN

CO<sub>2</sub> Combining Power Blood Sugar in Mgrs. Per Cent

Sex	Age	Diagnosis	Operation	Time of Operation in Minutes	Avertin in Cc.	Ether in Cc.	8 Hrs.				24 Hrs.			
							Before Opera- tion	After Opera- tion	After Opera- tion	Before Opera- tion	After Opera- tion	After Opera- tion	Before Opera- tion	After Opera- tion
F.	29	Hernia abdominal wall	Laparotomy	90	5.85	57	53.2	49.4	46.6	49.4	95	120	125	75
M.	15	Fibrosarcoma of thigh	Amputa. femur, remov. glands	120	3.5	120	58.9	48.5	51.3	54.1	95	148	125	110
F.	24	Ing. hernia	Bassini	60	7.0	150	59.5	51.9	50.4	61.3	86	130	90	95
M.	58	Carc. lip, metas. glands	Excision, plastic, remv. glands	150	5.4	120	50.4	59.4	50.4	53.2				
M.	45	Ing. hernia, biat- eral	Bassini	150	5.4	200	64.5	50.4	58.9		95	155	105	
M.	57	Carc. ear, metas. glands	Excis. plastic, remv. glands	180	6.4	150	55	54.1	55.7	63.0				
F.	34	Exop. goitre	Part. lobect.	90	5.3	150	48.5	38.1	49.4	44.7	72	100	75	110
F.	44	Exop. Goitre	Doub. par. lobect.	120	4.3	180	54.8	50.0	51.9	54.8	100	140	124	105
M.	35	Ing. hernia, bilateral	Bassini, bilateral	150	5.0	180	55.0	54.1	49.4	53.2				
Gas, Nitrous Oxide, Ethylene														
F.	54	Adenoma of thyroid	Extirpation of adenoma	60	6.6	N <sub>2</sub> O	54.8	55.7	51.3	52.2	110	125	116	110
F.	29	Pyosalpinx, append. chron.	Laparotomy, appen- dectomy, ovaric- tomy	150	4.3	N <sub>2</sub> O	59.5	56.7	59.5	59.5	105	152	155	115
F.	54	Carc. breast	Rad. operation	150	4.9	N <sub>2</sub> O	61.7	57.9	51.3		60	96	100	
F.	63	Cholethiasis ulcers stomach	Cholecystectomy, gastroenterostomy	160	4.6	N <sub>2</sub> O	53.2	43.8	47.5	49.4	60	148	140	135
M.	51	Exoph. Goitre	Double partial lo- bectomy	120	4.9	C <sub>2</sub> H <sub>4</sub>	52.8	51.0	51.0	53.8	100	120	145	115
F.	41	Fibroma of breast	Amputa. of breast	75	4.3	C <sub>2</sub> H <sub>4</sub>	53.	57.0	59.8	58.9	100	115	130	105

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Avertin and  $N_2O$  shows a still better picture as far as  $CO_2$  combining power and blood sugar is concerned. There is a little drop of  $CO_2$  combining power. Very often the rate remains within normal limits, and even immediately after operation it is rarely below 50.

The hyperglycæmia is of small amount and short duration. A few instances of avertin ethylene give a favorable view of the influence of this combined avertin gas method. There is no particular remarkable decrease of  $CO_2$  combining power. We consider, therefore, the combination of avertin and gas  $N_2O$  as well as  $C_2H_4$  as very efficient. The  $CO_2$  and blood-sugar determinations indicate very satisfactory clinical results.

### CONCLUSIONS

In one year, 700 operations were carried out under a combined method of small avertin doses with supplements of ether, nitrous oxide and ethylene (so-called avertin basis narcosis) without any fatalities. Complete avertin anæsthesia is not recommended. The usual avertin dose is from 60 to 95 milligrams per kilo.

If in any instance the  $N_2O$  is insufficient as a supplement for relaxation, it is supported by ether at the same time. Ether and gas act as a stimulant. Ethylene can be used in small concentrations (50-50 or 70-30).

The advantages of these combinations are that there is less toxicity with small avertin doses and stimulation of the respiratory and circulatory system is accomplished by the use of small amounts of ether or gas, which shortens the post-operative sleeping time.

Blood-pressure, pulse and respiration were measured every five minutes, and showed a more marked improvement after this combination had been used than after the complete avertin anæsthesia.

Investigations of  $CO_2$  combining power and blood sugar before and after operation show a relatively slight decrease of  $CO_2$  and a slight increase of short duration of the blood sugar. This method is advised as satisfactory on the basis of 700 anæsthesias given without complications.

### BIBLIOGRAPHY

- <sup>1</sup> Achelis: Saeurebasenhaushalt und Operationsgefahrung. Narkose u. Anæsthesie, No. 11, S. 541, 1928.
- <sup>2</sup> Achelis: Leberschaedigung und Operationsgefahrung. Zentralblatt f. Chirurgie, No. 39, S. 2454, 1929.
- <sup>3</sup> Anschuetz, Specht, Tiemann: Die Avertin-Narkose in der Chirurgie. Ergebnisse der Chirurg. u. Orth., Bd. xxiii, 1930.
- <sup>4</sup> Atkinson, and Ets: Journ. of Biol. Chem., vol. lii, 1922.
- <sup>5</sup> Austin and Jonas: Americ. Journ. Med. Sciences, Bd. cliii, p. 81, 1917.
- <sup>6</sup> Bruger, Burne, Wesley, and Dreyer: Effects of Avertin on Liver Function, Alkali Reserve and Concentration of the Blood, etc. Amer. Jour. of Surgery, vol. ix, p. 82, 1930.
- <sup>7</sup> Caldwell, and Cleveland: Surg., Gynec., and Obstet., vol. xxv, p. 22, 1917.
- <sup>8</sup> Carter, W. S.: Arch. of Internal Med., vol. xxvi, p. 319, 1920.
- <sup>9</sup> Crile, and Menten: American Jour. of Physiol., vol. xxxviii, p. 225, 1915.

- <sup>10</sup> Domanig: Individuelle Dosierung der Avertinbasisnarkose. Zentralblatt f. Chir., No. 35, S. 2191, 1929.
- <sup>11</sup> Floerchen, and Mues: Deutsche Zeitschrift f. Chirurgie, Bd. ccxxvii, 1930.
- <sup>12</sup> Franken: Die Allgemeinnarkose: Berichte ueber die ges. Gynækologie Geburtshilfe u. Grenzgebiete, Bd. xv, Heft 6, 1929.
- <sup>13</sup> Guttman: Rectal Narkosis with Avertin Anæsthesia and Analgesia, vol. ix, No. 6, p. 279, 1930.
- <sup>14</sup> Henderson, and Haggard: Journ. of Biol. Chem., vol. xxxiii, 1918.
- <sup>15</sup> Killian: Zur pharmakologischen Wirkung von Avertin. Zentralblatt f. Chir., No. 32, S. 1997, 1927.
- <sup>16</sup> Killian: Ergebnisse mit der Avertinnarkose. Narkose u. Anæsthesie, No. 1, S. 16, 1928.
- <sup>17</sup> Killian: Weitere experimentelle Erfahrungen mit Avertin: Narkose u. Anæsthesie, No. 3, S. 119, 1928.
- <sup>18</sup> Lendle: Experimentelle Untersuchungen ueber Dosierung u. Elimination des Avertins. Narkose u. Anæsthesie, No. 5, S. 239, 1928.
- <sup>19</sup> Lendle: Ueber die Bedingungen der Basisnarkose bei kombinierten Narkoseverfahren. Klin. Woch., No. 35, 1930.
- <sup>20</sup> Lendle: Archiv. f. exp. Pathol., vol. cxliv, heft 1/2, S. 76, 1929.
- <sup>21</sup> Lendle, and Tunger: Klin. Woch., No. 28, S. 1923, 1930.
- <sup>22</sup> Luckhardt, L., and Carter: Ethylene as a Gas Anæsthetic. Jour. Med. Assoc., vol. lxxx, p. 144, 1923.
- <sup>23</sup> Luckhardt, and Lewis, Dean: Clinical Experiences with Ethylene Oxygen Anæsthesia. Jour. Amer. Med. Assoc., vol. lxxxi, p. 1851, 1923.
- <sup>24</sup> Lundy: Staff Meetings of the Mayo Clinic, vol. iv, p. 324, 1929.
- <sup>25</sup> Parsons: Avertin. Brit. Med. Jour., No. 3639, p. 554, 1930.
- <sup>26</sup> Puckner: Preliminary Report of the Council: Avertin. Jour. of the Amer. Med. Assoc., vol. xcv, No. 19, S. 1427, 1930.
- <sup>27</sup> Rehn, and Killian: Indikationen der Schmerzbetaeübung im Drück.
- <sup>28</sup> Rehn: Deutsch. Med. Wochenschrift, S. 2003, 1928.
- <sup>29</sup> Speidel: Avertin Basal Anæsthesia. Clinical Observations. Report of 80 Cases.
- <sup>30</sup> Straub: Rectalnarkose. Resorption u. Dosierung. Muench. Med. Woch., No. 14, S. 593, 1928.
- <sup>31</sup> Straub: Ausscheidung u. Nebenwirkung: Muench. Med. Wochenschrift, No. 30, S. 1279, 1928.
- <sup>32</sup> Van Slyke, Austin, and Cullen: Jour. of Biol. Chem., vol. liii, 1922.
- <sup>33</sup> White, Charles, and Kreiselmann: Avertin Anæsthesia. Surg., Gynec., and Obstet., vol. li, No. 3, p. 361, 1930.
- <sup>34</sup> Widenhorn: Deutsche Zeitschrift f. Chir., Bd. ccxvi, S. 163, 1929.
- <sup>35</sup> Wymer: Saeure-Basenverhaeltnisse bei der Rectalnarkose. Ztbl. f. Chir., No. 39, 1927.
- <sup>36</sup> Wymer, and Fuss: Saeurebasenverhaeltnisse bei der Aether-Chloroform und Avertin-Narkose. Narkose u. Anæsthesie, No. 6, p. 283, 1928.



## A STUDY OF SPINAL ANALGESIA BASED UPON 357 PERSONAL CASES

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SPINAL analgesia has never been favored with universal acceptance. Neither can it be truly said that the method has received steadily increasing endorsement. To reach its present status, which is apparently somewhat favorable, the method has been subjected to intervals of commendation and condemnation. It is now a routine method with many surgeons and is frequently employed by many others. That it cannot be used as a universal anæsthetic is readily granted, but through development of factors of safety, it has been accepted as the procedure of choice in many conditions and is generally conceded to be a necessary addition to the anæsthetic methods of every surgeon or anæsthetist. Spinal analgesia has passed the experimental stage and now stands as a reliable and satisfactory method of analgesia which cannot be excelled within the scope of its indications. As it is, a special technical method, spinal analgesia has never proved safe for routine use, but if employed skillfully, the mortality and morbidity compare very favorably with other types of anæsthesia.

*History.*—After Corning<sup>1</sup> of New York unintentionally used spinal analgesia, he suggested its surgical applicability in 1894, and four years later Bier<sup>2</sup> of Kiel proved its feasibility, and endorsed it for surgical use. The next report of the use of spinal analgesia in America was made by Matas<sup>3</sup> in December, 1899, in which he told of injecting a 1 per cent. solution of cocaine into the spinal canal between the fourth and fifth lumbar vertebræ and obtained analgesia sufficient to perform a hæmorrhoidectomy. Tait and Caglieri<sup>4</sup> are credited with having performed an ostectomy of the tibia under spinal analgesia on October 26, 1899, but their work was not reported until April, 1900. The method soon became popular especially in America. In France, Tuffier,<sup>5</sup> was responsible for bringing the procedure into prominence. With the wide acceptance of the method came a number of variations of a technic that at best was poorly understood. In 1900 Morton<sup>6</sup> used a spinal injection of cocaine to produce general anæsthesia sufficient for operations on any part of the body. Eight years later this same method was popularized by Jonnesco.<sup>7</sup> Spinal analgesia, and unfortunately very frequently spinal "anæsthesia," was heralded with such wide acclaim that very early the disastrous results outweighed the favorable ones. Only cocaine was available; the technic at best was crude; and there can be no wonder that the method was soon unpopular. Bier, its original endorser, was as definite as anyone in denouncing indiscriminate use of spinal analgesia and, as is still true today, this exemplifies the fact that those who know most

about the method are most critical as to the indications for its employment. These early bad results are even now a basis for much skepticism and still somewhat overshadow the increasingly good results. In 1904 stovaine was introduced and was soon popularized, especially by Babcock<sup>8</sup> in America. His results were remarkably better than any previously obtained, but were still not all that could be wished. His recent good results have, however, become outstanding. During the past few years renewed interest in spinal analgesia has been manifested, no doubt due in a large part to the commendable work of Pitkin,<sup>9</sup> and to the availability of ephedrine with which to prevent alarming lowering of the blood pressure. With the present wave of enthusiasm has come the usual number of rediscoveries of variations of technic and application of spinal analgesia. Koster<sup>10</sup> has enthusiastically revived the procedure which in 1910 Jonnesco<sup>7</sup> said was "a new one and altogether distinctive, because I have generalized spinal anæsthesia, adopting it to all operations on any part of the body."

*Advantages.*—The surgeon who has used spinal analgesia is always reluctant to dispense with it. The advantages are manifold. Granting that the prime requisite of all anæsthetics is safety, spinal analgesia can be made safe and therefore allow the patient and the surgeon to be benefited by its advantages. Pre-operatively, patients need not be denied fluids unless the type of operation contra-indicates it. Effective prophylaxis of acidosis can, therefore, easily be continued uninterrupted. In emergency operations not infrequently the pre-operative treatment must of necessity be reduced to a minimum. Spinal analgesia will often prove to be a choice method under these circumstances.

Some patients are distressed by the anticipation of loss of consciousness and are particularly grateful for some anæsthetic method other than general anæsthesia. The patient who has on different occasions had inhalation anæsthesia and spinal analgesia expresses a most critical opinion. It is significant that such a patient almost invariably elects spinal analgesia when a third operation must be performed. The surgeon who is accustomed to operating upon patients under inhalation anæsthesia is particularly impressed with the surprising ease with which he can accomplish most of the steps of the operation when using spinal analgesia. Relaxation is more complete than can be obtained even by deep ether narcosis. Retraction of an abdominal incision is hardly necessary. The intestines are contracted and fall away from the abdominal wall so completely that gauze packs are rarely needed even for operations requiring wide exposure of the operative field. Respiration is quiet, and unaccompanied by coughing or straining, thereby allowing the surgeon to work unhampered by extraneous movements. Operative procedures are facilitated and trauma is minimized. Very soon after operation the patient can be allowed to take fluids. Nausea or vomiting is infrequent. Post-operative distention is not unusual after inhalation anæsthesia and is always an annoying and frequently a disastrous complication if it occurs. Distention is rarely observed after spinal analgesia. Peristalsis is augmented

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by the uninhibited impulses from the vagus nerves, and after cessation of analgesia normal peristalsis is quickly reestablished and meteorism prevented. Urinary retention is no more frequent than after other types of anæsthesia. The incidence and seriousness of post-operative pulmonary complications are possibly reduced. Spinal analgesia has been definitely proved to have no deleterious effect on the normal heart, kidneys, or liver; and even when these organs are diseased, spinal analgesia is well tolerated.

*Disadvantages.*—The science of surgery knows but few ideal procedures. Spinal analgesia would be unique if it had no disadvantages. The method is highly technical, but is simple enough to be mastered by those who are willing to devote sufficient time to its study. It offers to the surgeon a method of analgesia over which he has direct supervision and its efficacy parallels the surgeon's technical efficiency in its use. Alarming lowering of the blood pressure has formerly been a classical untoward reaction. Appropriate doses of ephedrine given before induction of spinal analgesia usually prevent this condition. If reduction of the blood pressure should occur, it is temporary and its onset is within a few minutes after the induction of analgesia and is well tolerated because the patient has not been subjected to operative shock.

Spinal analgesia should not be used for operations above the diaphragm, or at least to do so is dangerous and subjects the patient to unnecessary risk. There is no difficulty in establishing analgesia to a higher level—even of the scalp; indeed great care must be taken in order to prevent a maximum diffusion of the anæsthetic agent. Regional limitation of the analgesia, therefore, narrows the scope of the applicability of spinal analgesia. The length of the analgesic period when novocaine is used is one and one-half hours or two hours. The dose can be safely increased to produce analgesia for two hours in nearly every instance. It seems that all, except very unusual abdominal operations, should be completed within this time. If the operation must, for some reason, be prolonged beyond this time, other forms of anæsthesia must be resorted to or a second spinal injection may be given.

Trauma is an accompanying factor when, for any reason, a spinal puncture is done. Likewise, the possibility of introducing organisms is always present. Aseptic technic should prevent the latter and if small caliber, blunt beveled needles are skillfully used, the factors of trauma should be negligible. Certainly more spinal punctures are being done as diagnostic and therapeutic procedures than for the purpose of inducing spinal analgesia. They all carry the same possible dangers, but little has been said to discourage employing spinal puncture for diagnosis. Headache has occurred with sufficient frequency to warrant consideration. Its causes are clearly understood at this time and definite, efficient preventive methods are now commonly employed. Vomiting may occur, but when marked, is usually evidence of high diffusion of the analgesic drug and should not accompany properly controlled spinal analgesia. The peculiar phenomenon of temporary paralysis of the abducens nerve has been reported, especially by the earlier observers. This has

not been observed recently as new, less toxic drugs have been more carefully employed.

*Contra-indications.*—Spinal analgesia can be safely employed routinely to produce analgesia below the diaphragm with few, yet very definite, exceptions. The margin of safety is never great, and to disregard contra-indications is to invite disaster. Patients must be selected for spinal analgesia only after careful individual consideration. A careful history must be taken and a thorough examination made to elicit and evaluate factors which might contra-indicate spinal analgesia. Anaesthesia for imperative operations is often a difficult problem. Shock is frequently present, and the risk is great regardless of all precautions. The uninitiated may feel that in a "bad risk" case spinal analgesia is the method of choice. Any patient in shock tolerates spinal analgesia poorly and in such cases with acute shock or hæmorrhage spinal analgesia should not be administered. Such patients would, however, tolerate inhalation anaesthesia equally as poorly, and if some operative intervention is imperative, it could be more safely performed with local or regional analgesia. Indeed there are few indications for operations being done in the presence of shock. If the shock is relieved, spinal analgesia may safely be employed.

Patients with hypotension have previously been considered unsuited for spinal analgesia. This is generally true only if the hypotension is "acute" as from shock or hæmorrhage, which has been mentioned previously. With appropriate doses of ephedrine hypotension should not prove an absolute contra-indication. The author has repeatedly employed spinal analgesia successfully in patients whose systolic blood pressure was less than 100 millimetres of mercury.

Extreme cardiac decompensation and decreased vital capacity contra-indicate inhalation anaesthesia as well as spinal analgesia. The surgeon must, therefore, use local analgesia if operative procedures are imperative. Acute central nervous system disease, brain or spinal cord tumor, or neurosyphilis are reasons for not using spinal analgesia. Septicæmia is a contra-indication to spinal puncture and localized abscesses or ulcers at the site of puncture obviously prevent the introduction of a spinal needle.

All of the contra-indications cannot be considered here, but if spinal analgesia is to be employed successfully, contra-indications cannot be too carefully and honestly weighed in each individual case.

*Indications.*—As is true in other surgical procedures, the individual's adeptness is an important factor in answering the question as to when spinal analgesia should be used. Surely those who use spinal analgesia frequently have safely widened its field of application, and perhaps there should be less criticism of this extended scope of indications when thus used with expert efficiency. Spinal analgesia has met its severest trials because so many surgeons have reserved it for use in "bad risk" cases. The elderly, emaciated patient has been the characteristic type for which spinal analgesia has been



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used. Stanton,<sup>11</sup> in 1927, sent a questionnaire to 1,000 surgeons. Of the 622 answering the question: "Do you use spinal anaesthesia; if so, in what class of case do you use it?": 419 stated definitely that they did not use spinal analgesia, and of those who used it, 90 per cent. stated definitely that they used it only in special types of "bad risk" cases. It seems logical to remark in this connection that the type of anaesthetic which is safest for the "bad risk" is just as safe for the "good risk" cases. Although spinal analgesia has had to survive the test of being used on patients who were admittedly poor anaesthetic risks, it is now well known that, although spinal analgesia can be used under these circumstances, its greatest scope of usefulness does not lie within this field.

In the presence of marked arteriosclerosis spinal analgesia may not be used to good advantage, but not infrequently conditions associated with the arteriosclerosis make other forms of anaesthesia still more definitely contra-indicated. Nephritis and cardiac disease are frequently present and arterial hypertension is the rule. Such patients are far from ideal subjects for spinal analgesia but tolerate spinal analgesia as well as any other of the usual forms of anaesthesia. Some have thought that since lowering of the blood pressure frequently accompanies spinal analgesia that patients with arterial hypertension would be well suited for spinal analgesia. It cannot be stated too emphatically that this is not true. A sudden lowering of the blood pressure is even more disastrous to these patients than a similar decrease of blood pressure would be to the normal individual. Fleming and Naffziger<sup>12</sup> have called attention to the frequency of coma, hemiplegia, and other symptoms, usually attributed to apoplexy, which occur in individuals with extreme hypertension and are not due to the rupture of a cerebral vessel, but are due to cerebral anaemia resulting from a sudden decrease in blood pressure. Although spinal analgesia is not contra-indicated by hypertension *per se* it should be used with extreme caution in the presence of very high blood pressure. Marked fluctuation of the blood pressure is disastrous. Ephedrine must be used very cautiously if it is employed at all. An increase of the blood pressure may cause apoplexy and a decrease may cause fatal cerebral anaemia.

It has been repeatedly shown that spinal analgesia does not injure the parenchymatous organs, and therefore it will prove to be the anaesthetic method of choice in patients with definite renal disease. The diabetic patient tolerates spinal analgesia better than most forms of inhalation anaesthesia. Acute pulmonary disease is a classical contra-indication to inhalation anaesthesia. It cannot be definitely said that the instance of pulmonary complications is remarkably decreased following spinal analgesia. Most surgeons are reluctant, however, to use inhalation anaesthetics in the presence of respiratory disease. Spinal analgesia will prove most valuable in patients with intestinal obstruction. Not only does spinal analgesia serve as a valuable therapeutic agent by blocking the splanchnic nerves, but it is also an invaluable aid to the surgeon because relaxation is so perfect and the intestine



so contracted that the operation can be speedily performed with a minimum amount of trauma.

Spinal analgesia is of value in obstetrics. The author has had occasion to use this form of anaesthesia in several cases and has been impressed by the favorable results. A special technic must be employed, however, and a report of these cases will be made later. In this series, the only use in obstetrics recorded is that of caesarean section.

*Accompanying Phenomena.*—Spinal analgesia is induced by introducing the drug into the spinal fluid which bathes the intradural tissues and hence brings the anaesthetic solution into direct contact with the nerve roots. The

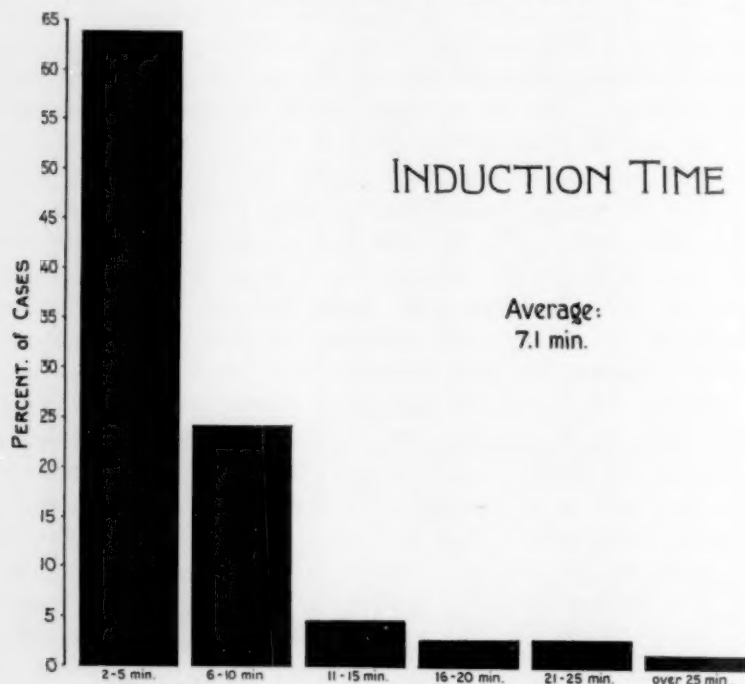


CHART I.—As is shown by the blocks, almost 90 per cent. of the spinal analgesias were induced within ten minutes. The small per cent. requiring a longer period of time represent those cases in which a second injection was necessary.

drug is quickly absorbed by the nerve roots both in the spinal canal and for about two centimetres beyond their exit. Analgesia cannot be established gradually by slowly administering the drug, but occurs at once from a single injection and cannot be diminished. Also, if analgesia is insufficient, it cannot be increased except by a second injection. The cord itself is probably not very deeply penetrated by the analgesic drug. If the analgesic agent is held in a restricted area, the nerves thus bathed by the concentrated solution will be permeated quickly and diffusion will be prevented. If wide diffusion occurs, the drug will be most effective at the point of injection, but at no point will there be deep penetration of the roots, and the duration of analgesia will be expectedly less or may be insufficient. If a large dose of such

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a diffusible drug is given in order to insure sufficient blocking of the nerve roots, distressing and dangerous symptoms will occur from such an extensive analgesia.

The first nerve roots to be affected are the sensory fibres. Their position favors ready contact with the injected analgesic drug and these fibres are less resistant to the penetration of the drug. Loss of sensation, therefore, is noted first and is most complete and lasting. The motor roots are less susceptible but are next blocked, although not completely, unless certain drugs are used which have a special affinity for the anterior roots. The sympathetic nerve fibres whose function is vasomotor control are last affected. In an ideal spinal analgesia the sensory nerve roots would be blocked, but conduction would be uninterrupted in the motor roots. These anterior or motor roots from the second thoracic to the first lumbar segment contain the white rami communicantes, and therefore an analgesic involving this section would cause paresis of the sympathetic system in direct ratio to the number of anterior nerve roots involved. When such an involvement is extensive, cardiac, vasomotor, and respiratory depression results. A blocking of all the motor and sensory roots to the level of the first thoracic segment results in a maximum decrease of the blood pressure. To extend the analgesia to the level of the fourth cervical segment is to block the phrenic nerves, and diaphragmatic paralysis then results. As the accessory muscles are paralyzed before the diaphragm, if phrenic nerve anæsthesia occurs, we are then confronted with a very critical situation—respiratory failure. It is, therefore, apparent that the ideal spinal analgesia should involve as few motor roots as possible and certainly there should be no analgesia to a level higher than is indicated for infra-diaphragmatic operations. Sufficient loss of sensation to permit operations about the head does not indicate a high motor anæsthesia but simply indicates its possible concomitant occurrence. Loss of sensation frequently occurs without motor paralysis, but it surely seems unwise to attempt to obtain loss of sensation at levels so high that if concomitant motor paralysis should occur the results would be disastrous. Undoubtedly, when diffusible analgesic drugs are used, some degree of blocking almost uniformly extends to a high level. It is fortunate, however, that in diffusing, the solution becomes so dilute that complete motor anæsthesia does not occur in the upper segments.

The vagus nerve has an extensive distribution in the thorax and abdomen. Its action directly opposes the sympathetics. Spinal analgesia does not, of course, affect the vagus nerve, but on the contrary removes the inhibiting force of the sympathetics and allows the vagus nerve to exhibit unrestrictedly a depressor action in the thorax and a motor accelerator action in the abdomen. The cardiac and respiratory rates are slow. The splanchnic vessels dilate, peristalsis is augmented, and the intestines are contracted.

The dose of the drug injected is always small in so far as systemic toxicity is concerned. Babcock<sup>8</sup> has said that: "In no other way can so extensive an analgesia be produced with so small a dose of a drug." The

toxicity is therefore of secondary importance to the more critical question of diffusion of the drug in the cerebrospinal fluid. Lowering of the blood pressure occurs in almost exact proportion to the height of the spinal analgesia. In order to facilitate operations in the upper abdomen, it is necessary to produce an intraspinal block to the level of the seventh thoracic segment. No severe and uncontrollable vascular or respiratory symptoms should result from such a procedure, and appropriate doses of ephedrine given prior to the induction of analgesia efficiently prevent any alarming fall of blood pressure. If analgesia is required for operations below the level of the umbilicus, analgesia of the spinal nerve roots is needed only to the level of the tenth thoracic

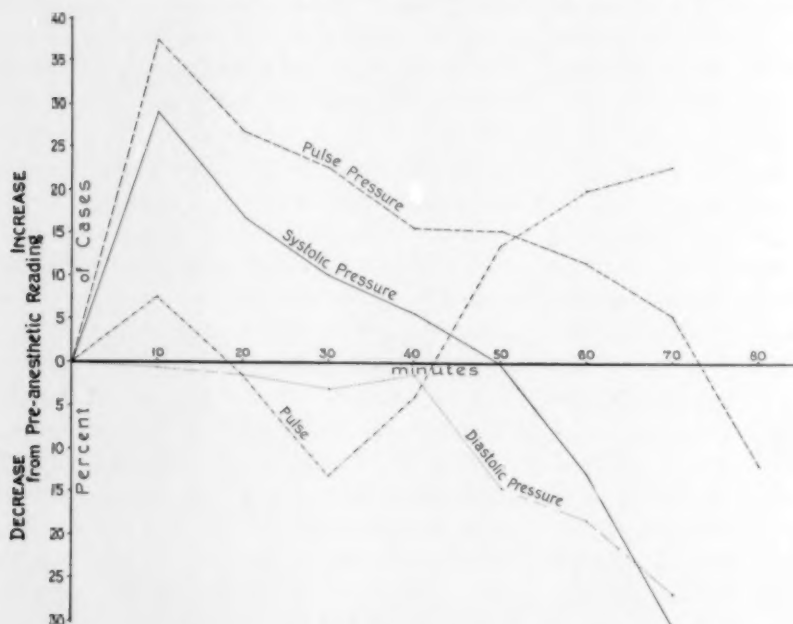


CHART II.—These curves are drawn from determinations on 357 cases of spinal analgesia induced with spinocain. The curves illustrate what is known clinically: viz., that the systolic blood pressure is increased at the early part of the anesthesia and gradually falls as the operation progresses and shock is superimposed upon the anesthetic. At fifty minutes it is seen that the systolic pressure is decreased sharply. A decrease at this late period must be attributed to operative trauma. The diastolic pressure shows very little change until the systolic pressure drops sharply when it shows a similar drop. The pulse is slightly accelerated at first, no doubt due to the use of ephedrine, and then remains slow for forty-five minutes and then shows a marked increase in longer operations. The pulse pressure is seen to behave very similar to the systolic blood pressure.

segment. Only a very slight degree of vasomotor depression should accompany such an analgesia. Operations below the iliac crests can be performed with analgesia to the level of the first lumbar segment, and perineal operations may be successfully done by blocking only those nerves which leave the dural sac in its caudal tip. In either instance the systemic reaction is negligible.

*Drugs and Technics Used.*—The consideration of the diffusion of the analgesic drug has always been paramount. Bier recognized this fact and early experimented with cocaine, but had only mediocre success. Fournau<sup>13</sup> discovered stovaine in 1904, and as this drug proved to be less toxic than

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cocaine, considerable improvement in spinal analgesia immediately followed its introduction. A characteristic action of stovaine is the marked temporary motor paralysis which occurs immediately after intradural injection. This is due to the affinity of stovaine for the anterior roots. As motor root analgesia is perhaps less desirable, stovaine has not maintained its popularity, especially since the introduction of novocaine. Apotheresine has been used in a considerable number of cases of spinal analgesia, especially during the World War. Orth<sup>14</sup> reports excellent results with apotheresine and Schutz<sup>15</sup> reported its use in 2251 cases. In general, however, it has been discarded in favor of less toxic drugs. The same might also be said of tropococaine, tutocaine, butyn, and many others. Novocaine has been subjected to very critical study and is now generally recognized as the most satisfactory local analgesic. Its early use in spinal analgesia consisted in injecting the novocaine crystals put into solution by using distilled water, normal saline, or spinal fluid as a solvent. Very satisfactory results have been obtained by using accurate doses of novocaine crystals dissolved in spinal fluid. A long list of followers of this method might be named, but probably Labat's<sup>16</sup> name is more closely associated with this method than any other. At the present time this is undoubtedly the most popular technic and has given very excellent results. Stout<sup>17</sup> has recently called attention to "volume control" technic whereby controllability can be obtained. A relative degree of controllability can always be obtained by such simple considerations as regulation of dose, amount of spinal fluid used, rate and speed of injection, and site of puncture.

Outstanding objections to the use of crystalline novocaine in spinal fluid have been the short duration of analgesia and the lack of absolute controllability. Novocaine has been used in many different analgesic solutions, most of which have been intended to take advantage of a difference in specific gravity to acquire controllability. Barker,<sup>18</sup> Hepburn,<sup>19</sup> and Sise<sup>20</sup> have used a glucose solution which is heavier than spinal fluid, and have obtained satisfactory control of the diffusion to facilitate operations in the upper abdomen. The nerve roots very quickly absorb the novocaine from this solution and a change of the patient's position is made possible if such becomes necessary. In view of the fact, however, that one of the most efficient methods of combating cerebral anemia is the placing of the patient in the Trendelenburg position, it would seem dangerous to use a solution to produce spinal analgesia at a high level which would prohibit lowering the head at any time if syncope should occur. Pitkin<sup>9</sup> has developed a viscid novocaine solution of light specific gravity in order to take advantage of the Trendelenburg position. Such a procedure is not new, but in view of the success of the method since its introduction, it would seem that the preparation is more efficient than its predecessors. The ideal spinal analgesic should be one of low toxicity and definite controllability. Pitkin's solution would seem to approach this ideal.

Novocaine is still the sheet anchor of local, regional and spinal analgesia. Although it has been mixed with many different substances, novocaine

probably works most efficiently when mixed with common sense and a thorough knowledge of the phenomena accompanying spinal analgesia.

*Analysis of Cases.*—The author has used crystalline novocaine dissolved in spinal fluid as has been stated, in a previous report,<sup>21</sup> and although the results were not unsatisfactory, certain undesirable features were evident. The short duration of the analgesia with novocaine crystals was a serious handicap. Control of the level of analgesia was only relative. No serious complications developed, however, and no deaths occurred. Recently, Pitkin's method has been adopted and the last 357 consecutive spinal analgesias have been induced according to his technic. There seem to be some outstanding advantages. There has been no difficulty in limiting the level of

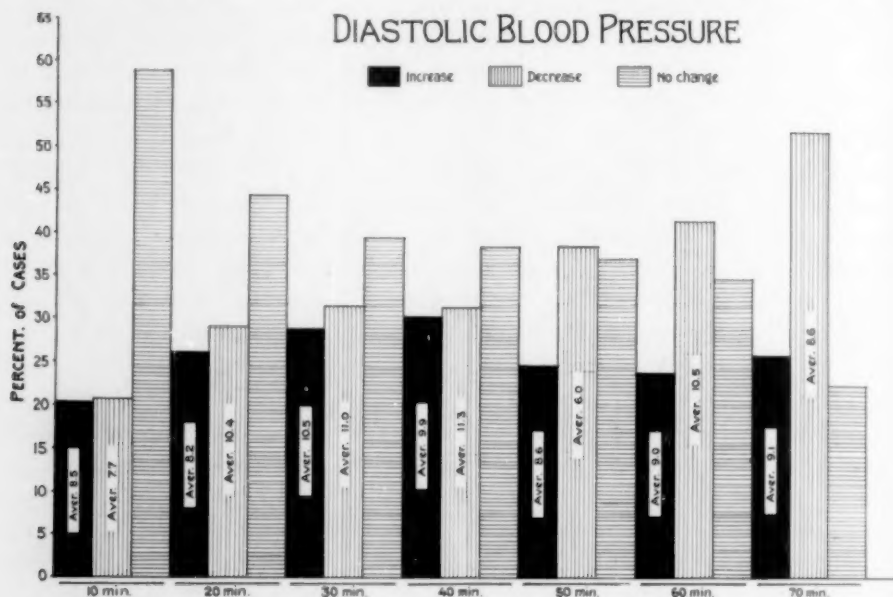


CHART III.—The diastolic blood pressure is little affected early in the anæsthetic, as is shown by the very large percentage of cases which show no changes. This percentage decreases, however, so that at seventy minutes those cases showing a decrease are the largest number of cases. The figures on the blocks show the average increase or decrease in the diastolic blood pressure in millimetres of mercury.

analgesia, and the average duration of the effect of the drug is longer than was noted with novocaine crystals. It has been very unusual for analgesia to disappear in less than two hours, and in many instances operative procedures continued for two and a half hours without supplementary anæsthesia. The average length of time required for operations was forty-eight minutes. Satisfactory analgesia is always anticipated for one and a half hours, and in only a few instances has there been a shorter duration. In nine instances, operative procedures required longer than two and a half hours; inhalation anæsthesia was necessary as a supplement in three of these. In six cases, analgesia was present for less than one and a half hours and inhalation anæsthesia was necessary. The usual note on the chart indicates, however, that "gas was used while closing the incision." The higher the



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level of analgesia, the shorter the duration. Upper abdominal analgesia is expectedly maintained for a shorter period of time than analgesia of the lower extremities. Some of the longest successful analgesias were for prolonged orthopedic operations on the lower extremities. When localized perineal analgesia was obtained, it was of relatively short duration since only one-half a cubic centimetre of spinocain (fifty milligrams novocaine) was used.

In eight cases, a second injection of analgesic solution was necessary in order to establish the desired analgesia. In four others, a second injection would probably have made spinal analgesia adequate. In these four cases, the circumstances were such that second injection was not made. The usual

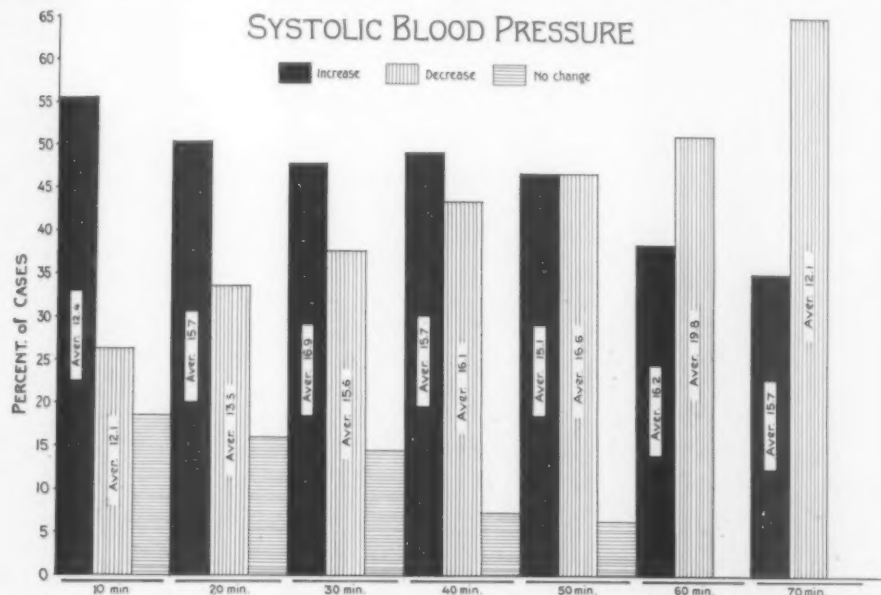


CHART IV.—The large number of cases showing an increase in the first ten minutes is probably due to the action of ephedrine and also due to the fact that the anæsthetic has been established only two or three minutes. As the anæsthetic continues and the operation progresses, it is well known that the systolic blood pressure decreases. At seventy minutes it is seen that those cases showing a decrease in the systolic blood pressure are nearly double those showing an increase. The figures on the blocks show the average increase or decrease in the systolic blood pressure in millimetres of mercury.

reason was that an impatient surgeon chose to proceed with local analgesia or general anæsthesia, rather than delay for a second spinal injection. Regarded in the light of success of the primary injection, all twelve of these cases can be regarded as failures. Failure is nearly always due to faulty technic, usually insufficient diffusion. There has been, therefore, no hesitancy about employing a second injection.

In one instance, satisfactory analgesia appeared twenty-five minutes after injection, but this is unusual. The average time elapsing between injection of the solution and establishment of the desired degree of analgesia was 7.1 minutes. (Chart I.) The doses recommended by Pitkin<sup>9</sup> have generally been used. For upper abdominal analgesia 3 cubic centimetres of spinocain have

been used routinely. In one instance 6 cubic centimetres were used, a second injection of the full dose having been made. In patients with a normal blood pressure, 50 milligrams of ephedrine was the usual dose and was given subcutaneously about five minutes prior to injection of the spinal analgesic solution. The dose of 100 milligrams of ephedrine was unusual and was given to "hypotensive" patients in whom "high" analgesia was necessary. Adrenalin has not been used in this series. In cases in which analgesia below the iliac crests was established, no ephedrine was used. In most of the patients a slight rise in the blood pressure was noted early, the blood pressure returning to normal or slightly below, as the operation progressed and the ephedrine effect became less. (Chart II.) This drop below normal does

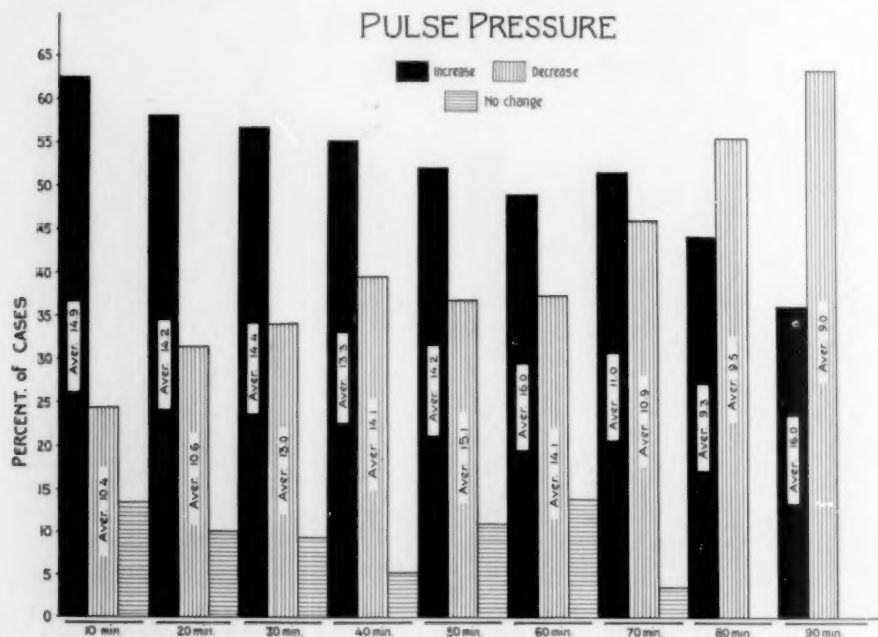


CHART V.—The pulse pressure is increased at the beginning of the anæsthetic, but consistently decreases as the anæsthetic and operation progress. The average increase or decrease of the pulse pressure is shown by the figures on the blocks.

not continue unless operative shock has been marked, for with the cessation of analgesia vasomotor equilibrium is quickly reestablished. Unless prevented, the blood pressure may drop to a sufficient degree to be alarming. This has formerly been a most frequent complication. It did not occur in this series, however, except in two cases in which the cause was plainly an unusual loss of blood. In one patient undergoing cæsarean section, a 46 millimetres of mercury decrease in the systolic blood pressure occurred fifty minutes after spinal injection, but during this time considerable bleeding had occurred. One patient became markedly exsanguinated from loss of blood from both uterine arteries during the course of a hysterectomy. The analgesia could hardly be blamed for the shock which occurred in this case.

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The systolic blood pressure usually showed a sharp rise during the first ten minutes after the subarachnoid injection of the analgesic solution. At the end of fifty minutes the systolic blood pressure returned to the pre-analgesic level. Any marked decrease, thereafter, can hardly be attributed to the spinal analgesia. If an operation is of long duration, some decrease in the systolic blood pressure must be expected. In those cases in which the operation was not prolonged and the patient was returned to bed, it was gratifying to see the absence of symptoms of shock. As has been said, this no doubt can be attributed to the disappearance of the primary depressive action of the spinal analgesia, which allows the patient to regain quickly a normal circulatory equilibrium. The variations of the pulse, diastolic blood

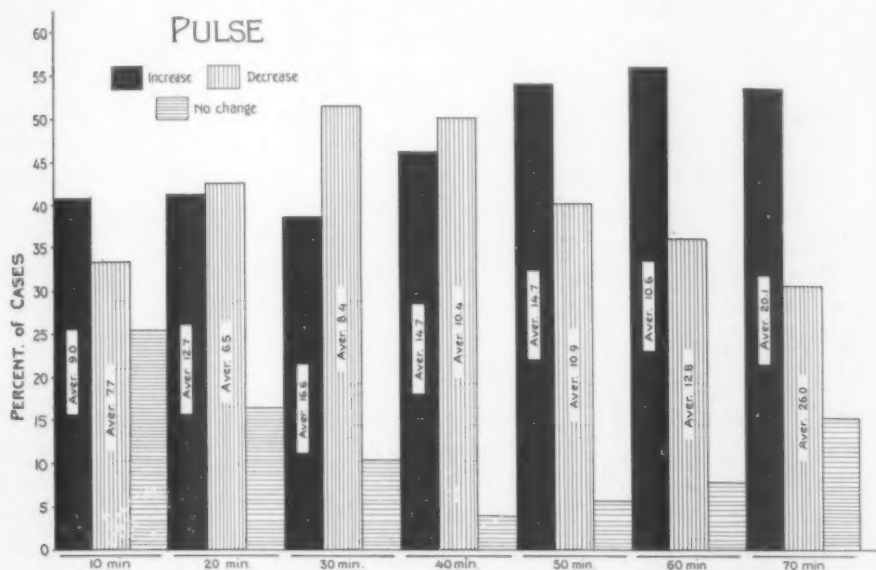


CHART VI.—A decrease in pulse rate is seen in most cases at the beginning of spinal analgesia. As the operation progresses it is seen that the number showing an increased pulse rate increases to almost double those showing a decrease. The average increase and decrease in pulse rate is shown by the figures on the blocks.

pressure, pulse pressure, and systolic blood pressure, are indicated in Chart II. The diastolic blood pressure was not markedly affected. Those changes from the pre-analgesic reading which occurred were not very great. (Chart III.) The systolic blood pressure showed considerably more variation (Chart IV) than did the diastolic blood pressure. The pulse pressure varied in almost exactly the same manner as did the systolic blood pressure. (Chart V.) The pulse was decreased at the beginning of the analgesia but increased in rate as the operation progressed. (Chart VI.)

Post-operative urinary retention has been present in about the same number of patients as has been noted following inhalation anaesthesia. There has been no case which required repeated catheterization. Most of the patients requiring catheterization during the first twenty-four hours were those who had had perineal or rectal operations.

The possibility of headache occurring post-operatively led the author to observe a routine of prophylaxis. Twenty-two gauge Pitkin needles were used routinely and especial care was taken not to allow the patient to make the slightest movement while the needle was *in situ*. Leakage from a large needle puncture or a rent in the dura, made by the patient's movement while the needle is in place, is the most common cause of post-spinal-puncture headache. A second type is due to blood, irritant solutions, or actual infection in the spinal fluid. Following operation, the bed was placed in the Trendelenburg position for twelve hours unless contra-indicated by other conditions, such as peritonitis. In this series no patient developed headache sufficiently severe to require special treatment. None complained of this symptom and only a few indicated its presence upon being questioned. Morphine was given routinely for post-operative pain, and undoubtedly this prevented many from complaining of a mild headache.

Vomiting has not been very frequent. Oxygen inhalations gave almost instant relief to those cases which exhibited some nausea during the period of analgesia. In all, 5 per cent. of the cases in this series exhibited some degree of nausea and vomiting during the analgesic period. In no case was post-operative vomiting severe.

There has been no example of ocular palsy, motor paralysis, or sphincteric incontinence. There has been no fatality which could be directly attributed to spinal analgesia.

#### SUMMARY

Three hundred and fifty-seven cases of spinal analgesia induced with spinocain are reported. Twelve failures occurred. Of these, eight obtained satisfactory analgesia after a second sub-arachnoid injection of spinocain. The remaining four received no second injection and operation was performed under inhalation anaesthesia. No deaths occurred which could in any way be directly attributed to the spinal analgesia. The length of the analgesia period was definitely more prolonged than when crystalline novocaine dissolved in spinal fluid was used. Satisfactory analgesia for one and one-half hours was obtained in nearly every case. The analgesia period was shorter when the level of analgesia was high, as for upper abdominal operations. There were two cases which showed an alarming fall in blood pressure. In both instances, however, a severe hæmorrhage had preceded the drop in blood pressure. Ephedrine was given routinely, and was apparently responsible for preventing the drop in blood pressure usually seen following the induction of spinal analgesia. Post-operative urinary retention which required repeated catheterization was not encountered in this series. Severe post-operative headaches did not occur. Nausea or vomiting occurred in 5 per cent. of the cases of this series. When this complication occurred, relief could be obtained by the administration of oxygen.

An analysis of the variations of blood pressure, pulse, and pulse pressure in the cases of this series is presented. This analysis was obtained from a

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study of records of these findings made every ten minutes during the period of analgesia.

The results seem to indicate some advantage of spinocain over crystalline novocaine, if careful technic is observed.

### REFERENCES

- <sup>1</sup> Corning, J. L.: Spinal Anæsthesia and Local Medication of the Cord. N. Y. M. J., vol. xlii, p. 483, 1885.
- <sup>2</sup> Bier: Versuche uber cocainierung des Rückenmarkes. Deutsche Ztschr. f. Chir., vol. li, p. 361, 1899.
- <sup>3</sup> Tait, D., and Caglieri, G.: Experimental and Clinical Notes on the Subarachnoid Space. J. A. M. A., vol. xxxv, p. 6, 1900.
- <sup>4</sup> Matas, R.: Concerning Spinal Anæsthesia. Editorial letter, Am. J. Surg., vol. v, p. 636, 1928.  
*Idem*: J. A. M. A., vol. xxxiii, p. 1659, 1899.
- <sup>5</sup> Tuffier, T.: Analgésie chirurgicale pour l'injection sous-arachnoidienne lombaire de cocaïne. Compt. Rend. Soc. de Biol., vol. ii, p. 882, 1899.
- <sup>6</sup> Morton, W. A.: Is the Subarachnoid Injection of Cocain the Preferable Anæsthesia Below the Diaphragm? Pacific M. J., vol. xliii, p. 801, 1900.
- <sup>7</sup> Jonnesco, T.: Technic for Intraspinal Generalized Anæsthesia. Presse Med., vol. xxxiv, p. 145, 1926.  
*Idem*: Am. J. Surg., vol. xxiv, p. 364, 1910.
- <sup>8</sup> Babcock, W. W.: Text-book of Surgery. Philadelphia, W. P. Saunders and Co., 1928.  
*Idem*: A New Method of Surgical Anæsthesia. Proc. Phila. Co. M. Soc., Phila., vol. vii, p. 152, 1905-1906.  
*Idem*: Spinal Anæsthesia: An Experience of Twenty-four Years. Am. J. Surg., vol. v, p. 571, 1928.  
*Idem*: Demonstration of Spinal Anæsthesia. S. Clin. N. Amer., vol. vi, p. 1, 1926.
- <sup>9</sup> Pitkin, G. P.: Intradural Sacral Anæsthesia with Spinocain. Brit. J. Anæ., vol. vii, p. 2, 1929.  
*Idem*: Spinocain, Controllable Spinal Anæsthetic. Brit. M. J., vol. ii, p. 183, 1929.  
*Idem*: Controllable Spinal Anæsthesia. Am. J. Surg., vol. v, p. 537, 1928.  
*Idem*: Controllable Spinal Anæsthesia. J. M. Soc. N. J., vol. xxiv, p. 425, 1927.  
*Idem*: Controllable Spinal Anæsthesia with Spinocain. Brit. J. Anæ., vol. vi, p. 68, 1928.
- Pitkin, G. P., and McCormack, F. C.: Controllable Spinal Anæsthesia in Obstetrics. Surg., Gynec., and Obst., vol. xlvii, p. 713, 1928.
- <sup>10</sup> Koster, H., and Weintrob, M.: Spinal Anæsthesia Fatalities. Am. J. Surg., vol. ix, p. 234, 1930.  
Koster, H.: Spinal Anæsthesia. Am. J. Surg., vol. v, p. 554, 1928.
- <sup>11</sup> Stanton, E. M.: The Anæsthetic Preferences of American Surgeons. ANNALS OF SURGERY, vol. lxxxvi, p. 273, 1927.
- <sup>12</sup> Fleming, H. W., and Naffziger, H. C.: Physiology and Treatment of Transient Hemiplegia. J. A. M. A., vol. lxix, p. 1484, 1927.
- <sup>13</sup> Frouneau, E.: Stovaine anesthésique local. Bull. d. Sc. Pharmacol., vol. x, p. 141, 1904.
- <sup>14</sup> Orth, D. A.: Spinal Anæsthesia. Am. J. Surg., vol. xxxix, p. 2, 1925.  
*Idem*: Strangulated Femoral Hernia. Surg. Clin., vol. iii, p. 201, Chicago, 1919.  
Orth, D. A., and Mueller, G.: A Plea for Spinal Anæsthesia. St. Paul Med. J., vol. xix, p. 204, 1917.
- <sup>15</sup> Schutz, C. B.: Spinal Anæsthesia. Surg., Gynec., and Obst., vol. xlvi, p. 281, 1928.
- <sup>16</sup> Labat, G.: Regional Anæsthesia; its Technic and Clinical Application. Phila., W. B. Saunders, 1922; Second Edition, 1928.
- Idem*: Elimination of Dangers of Spinal Anæsthesia. Am. J. Surg., vol. v, p. 625, 1928.



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- <sup>17</sup> Stout, R. B.: Spinal Anæsthesia, Volume Control Technic. Am. J. Surg., vol. vii, p. 57, 1929.  
*Idem*: Spinal Anæsthesia, Volume Control Technic. Wisc. M. J., vol. xxviii, p. 156, 1929.  
*Idem*: Spinal Anæsthesia; Blood Pressure Control. Wisc. M. J., vol. xxviii, p. 261, 1929.  
Stout, R. B., and Ewell, G. H.: Spinal Anæsthesia; with Remarks on Volume Control Technic. Wisc. M. J., vol. xxviii, p. 113, 1929.
- <sup>18</sup> Barker, A. E.: Clinical Experience with Spinal Analgesia in 100 Cases. Brit. M. J., vol. i, p. 665, 1907.
- <sup>19</sup> Hepburn, W. G.: Stovaine Spinal Analgesia. Am. J. Surg., vol. xxxiv, p. 87, 1920. (Anes. supplm.)
- <sup>20</sup> Sise, L. F.: Spinal Anæsthesia for Upper and Lower Abdominal Operations. New Eng. J. M., vol. cxcix, p. 59, 1928.  
*Idem*: Spinal Anæsthesia for Abdominal Operations. N. Y. State Jr., vol. xxix, p. 1182, 1929.  
*Idem*: Fatalities and Their Prevention. New Eng. J. Med., vol. cc, p. 1071, 1929.  
*Idem*: Lumbar Puncture Technic. Am. J. Surg., vol. v, p. 577, 1928.  
Sise, L. F., and Woodbridge, P. D.: Choice of Anæsthesia. M. J. and Rec., vol. cxxxi, p. 575, 1930.
- <sup>21</sup> Garside, Earl: Spinal Anæsthesia. N. O. M. and S. Jr., vol. lxxxii, p. 453, 1930.  
*Idem*: Some Observations on Spinal Analgesia. Med. Jr. and Rec., vol. cxxxi, p. 563, 1930.

## SPINAL ANÆSTHESIA

REPORT ON A SPINAL ANÆSTHESIA QUESTIONNAIRE AND A SERIES OF SPINAL ANÆSTHESIAS\*

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SPINAL anæsthesia is not a new method of preparing a patient for a surgical operation, but its latest wave of popularity has assumed great proportions and is still rapidly gaining in volume. The first wave of popularity in this country came between 1912 and 1917 following Jonnesco's visit to America advocating stovaine as the anæsthetic, but it was rather short-lived because of the high mortality rate due to the incomplete knowledge of the physiological action of the drugs used and also because of its injudicial employment. However, Wayne Babcock, of Philadelphia, and Rudolph Matas, of New Orleans, continued to use it with excellent results. Modifications, additions, and improvements have been added to the technic and armamentarium by Labat, Pitkin, and others, and today we consider spinal as a valuable and permanent addition to our list of anæsthetics.

There are numerous drugs used as spinal anæsthetics and various media used for dissolving them, but the purpose of this paper is not to discuss them in particular, believing that one will get the best results if he will perfect his technic with one certain solution and use it routinely. The real purpose of this paper is to report in detail 220 cases of spinal anæsthesia given since May 1, 1930, and also to report the results of a questionnaire concerning spinal anæsthesia sent out to 500 surgeons practicing in twenty of the large cities geographically distributed over the whole country.

(1) Is spinal anæsthesia safe when used correctly? (2) What is its usual effect on blood-pressure, pulse and pulse-pressure, especially during the operation? (3) What are its indications and contra-indications? (4) What are its advantages to the patient and the surgeon? (5) What are the post-operative complications? These are questions we will attempt to answer, using records and graphs to illustrate.

We believe that spinal anæsthesia is safe in both high and low abdominal surgery providing the dose of the anæsthetic, the method of injection, and the handling of the patient are correct. There was no anæsthetic death in our series, and there was but one patient whose systolic blood-pressure went below 50 millimetres of mercury. This case did not constitute a scare but ordinary procedures for combating a fall in blood-pressure were instituted. We do not believe that the spinal injection should be given by one inexperienced in its use. There are various, apparently minor, details necessary

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\*Read before the Minneapolis Surgical Society, May 22, 1931.

to its complete success, and one should use it only after repeated observations and then only when one experienced in its use can direct him for a time.

*Age and Sex of the Patients.*—Table I gives the ages of the patients in decades and the ratio of males to females in this series.

The number of patients in the second, third, fourth, fifth and sixth decades were about equally divided. There were none under ten years of age. We have avoided giving it to patients under ten years, but do not believe youth to be a serious contra-indication. Coöperation is lacking in the very young, and that is a serious handicap to the surgeon. Twenty-three, or about 10 per cent., were over sixty years of age. We have not considered advanced age as a contra-indication unless the systolic blood-pressure was extremely high (240) and the accompanying diastolic pressure comparatively low, or

AGES

DECADE	NUMBER OF CASES
1 - 10 years	0
10 - 20 years	43
20 - 30 years	37
30 - 40 years	45
40 - 50 years	40
50 - 60 years	32
60 - 70 years	19
70 - 80 years	4

Males 137; Females 83. =

220 = total

TABLE I.—Ages by decades and ratio of males to females.

unless the patient had a decompensated heart. Extreme hypotension (below 95 systolic), especially in adults, has been considered a contra-indication.

We have tried to limit the use of spinal anæsthesia in this series, as far as possible, to patients belonging to the good risk group, regardless of age, not wishing to discredit it by a high mortality rate in patients in whom it was used where the deaths were not definitely due to the anæsthetic.

The operations in this series are indicated in Table II.

It will be noted that there were no operations above the diaphragm. It is our opinion that operations above the diaphragm contra-indicate the use of spinal anæsthesia, the danger being paralysis of the voluntary muscles of respiration, and, when the anæsthetic reaches a little higher level (fourth cervical), paralysis of the phrenic nerve and, through it, the diaphragm.

*Blood-pressure Effects.*—By far the most interesting point in spinal anæsthesia is its effect on blood-pressure. The cause of the fall in pressure is unquestionably due to the paralysis of the white rami emerging from the anterior horn of the spinal cord. This paralysis results in a loss of vasomotor

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constriction in the splanchnic vessels and in a consequent accumulation of a larger volume of blood therein. This effect makes possible cerebral anæmia; hence the imperativeness of the Trendelenburg position. That the fall in pressure is greater in some than in others—all else being equal—is explained on the theory that the dentate ligament separating the anterior and posterior subarachnoid spaces is denser in some than in others, rendering the transfusion of the anæsthetic solution variable. Graphs I and II indicate the extreme variation of blood-pressures taken at five-minute intervals.

## OPERATIONS

Herniotomy (all varieties)	60	Gunshot wound of abdomen	1
Appendectomy	72	Lacerations of leg	1
Cholecystectomy	14	Excision of exostoses	1
Hemorrhoidectomy	6	Incision for cellulitis	1
Gastroenterostomy	1	Vasectomy	1
Gastric resection	3	Intestinal anastomosis	2
Pyloroplasty	4	Removal of cyst	1
Salpingectomy	6	Removal of foreign body	1
Hysterectomy	5	Orchidoplasty	1
Prostatectomy	2	Bowel resection	1
Anterior colporrhaphy	1	Exploration of common duct	2
Posterior colporrhaphy and perineorrhaphy	1	Exploratory laparotomy	4
Oophorectomy	2	Anal fistula	1
Incision of pelvic abscess	2	Ventral suspension	1
Fracture (Lane plate)	2	Amputation of leg	7
Osteomyelitis	5	Hydrocele	1
Correction of hallux valgus	1	Rectal abscess	2
Curettage	1	Pilonidal cyst	2
Nephrotomy for stone	1		

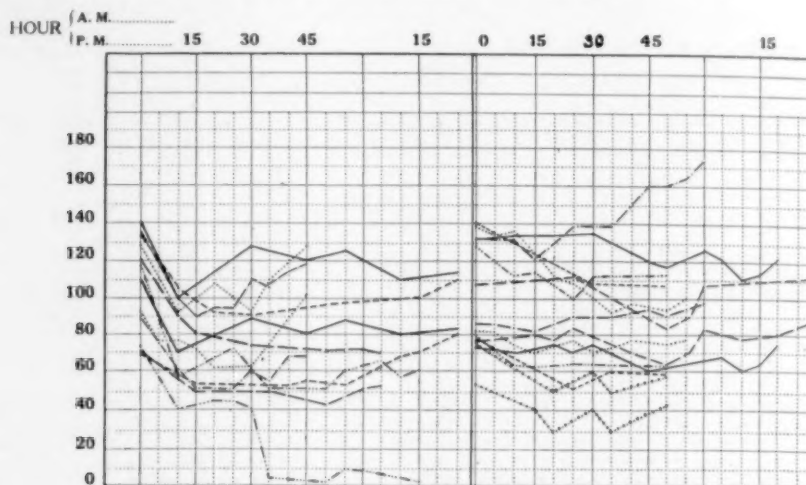
TABLE II.—Operations in this series.

It is impossible to foretell the blood-pressure behavior in any given case although a somewhat more uniform action has been noted where a subcutaneous injection of 50 milligrams of ephedrin has been given ten to fifteen minutes before the spinal injection.

Another of the graphs (III) indicates the blood-pressure behavior in four of our patients in whom the systolic blood-pressure was 170 or above.

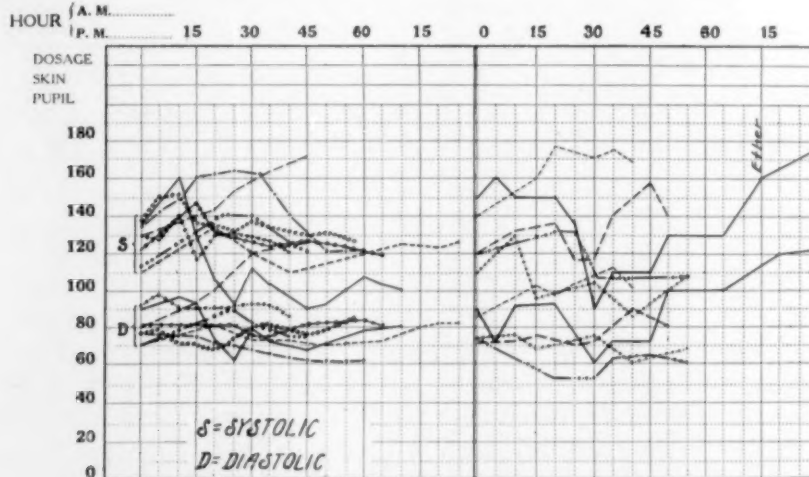
In one there was a precipitous drop from 230 to 90; in another there was a rise from 208 to 300; while in the others there was a moderate fall in pressure. The right side of this graph indicates the blood-pressure behavior in a man who had three amputations, two under nupercaine and one under novocaine

crystals dissolved in spinal fluid. The first amputation was above the ankle, the second just below the knee, and the third above the knee. The behavior is seen to be practically the same during the three operations.



GRAPH I.—On the left side are a group of blood-pressures which behave more or less similarly in that there is a moderate initial fall followed by a gradual rise of both the systolic and diastolic pressure. (The line indicating the systolic pressure matches the line indicating its associated diastolic pressure in each case.) On the right side is a group showing a more gradual fall followed by a gradual rise.

We have observed that there are four types of blood-pressure behavior under spinal anaesthesia. Graph IV illustrates the types and the percentages of each type.

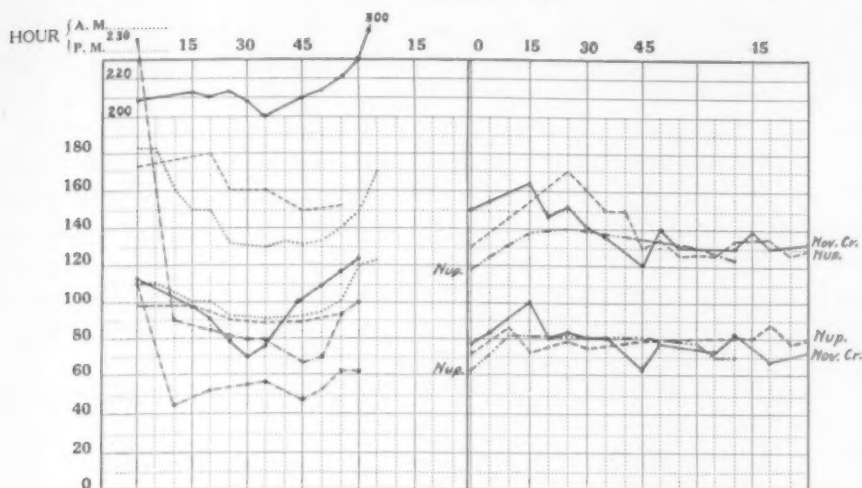


GRAPH II.—The left side shows an initial rise in blood-pressure in each patient instead of a fall. This is probably due to the action of ephedrin. The right side of the graph shows a few irregular types of blood-pressure.

In 70 per cent. of the patients there was a slight rise of pressure after the ephedrin injection followed by a moderate fall, and then a gradual rise to the pre-injection level. In 12 per cent. there was a precipitous drop followed by a slow rise. In 10 per cent. there was a moderate rise, but no secondary fall

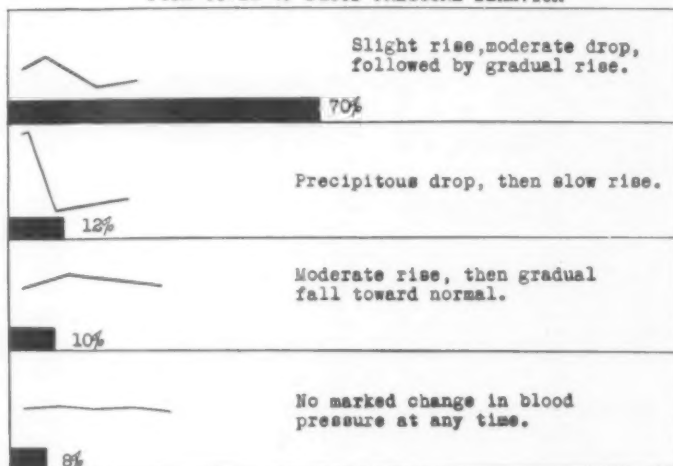


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GRAPH III.—On the left the behavior of the blood-pressure in four patients with hypertension is shown. On the right the similarity of the blood-pressure behavior in a patient in whom nupercaine was used twice and novocaine crystals once for three amputations of the leg at different times.

### FOUR TYPES OF BLOOD PRESSURE BEHAVIOR



- (1) Average time to lowest blood pressure was 30.6 minutes.
- (2) Greatest decrease in pressure was systolic 166 points, diastolic 70 points.
- (3) Greatest increase in pressure was systolic 70 points, diastolic 52 points.
- (4) Average decrease in pressure, in those in whom there was a fall, was systolic 34 points and diastolic 22 points.
- (5) Average increase in pressure, in those in whom there was a rise, was systolic 28.3 points and diastolic 21.3 points.

### PULSE PRESSURE CHANGE FROM HIGHEST TO LOWEST B. P.

Decrease	(62%)	Average decrease 23 points.
Increase	(30%)	Average increase 12.5 points.
Same	(8%)	

GRAPH IV.—The four most common types of blood-pressure behavior are shown above. The change in pulse-pressure determined at the time of the highest blood-pressure and again at the time of the lowest blood-pressure is shown below.

below the pre-injection level. In 8 per cent. there was no marked change in blood-pressure during the entire operation. The time required for the blood-pressure to return to the pre-operative level in those cases in which there was a fall varied from forty-five minutes to twenty-four hours. It came back most slowly in the hypertension cases. The average time to the lowest blood-pressure was 30.6 minutes. The greatest decrease in systolic pressure was 166 points, and in diastolic pressure 70 points. The greatest increase in systolic pressure was 70 points, and in diastolic pressure 52 points. The average decrease in those in whom there was a fall was systolic 34 points and diastolic 22 points. The average increase in those in whom there was a rise was systolic 28.3 points and diastolic 21.3 points.

A study of the behavior of the *pulse-pressure* is also very interesting. It was determined at the time the blood-pressure was the highest and compared with that determined when the blood-pressure was the lowest with the following results: In 62 per cent. of the series there was a decrease in pulse-pressure for an average of 23 points. In 30 per cent. of the series there was an increase in pulse-pressure for an average of 12.5 points. In 8 per cent. there was no change in pulse-pressure. These results are indicated graphically at the bottom of Graph IV. This record, we believe, is significant in that it shows that spinal anæsthesia tends to reduce pulse-pressure, and hence to stabilize circulation.

#### PULSE

Increased  20%

Constant  30%

Decreased  50%

Constant & decreased  80%

#### GRAPHIC INDICATION OF CHANGE IN PULSE RATE FROM BEGINNING TO END OF OPERATION

GRAPH V.—Note the tendency of the pulse rate to decrease under spinal anæsthesia, indicating stabilization of the circulation.

Graph V indicates the change in pulse rate in the cases of this series.

In 50 per cent. it decreased, in 20 per cent. it increased, and in 30 per cent. it remained constant. If the pulse rate in spinal anæsthesia is constant or decreased in 80 per cent. of the cases, the frequently appearing statement that its effects are those of shock is not wholly true.

*Indications and Contra-indications.*—We believe that spinal anæsthesia is indicated in: (1) Intestinal obstruction. (2) Surgery below the diaphragm on diabetics and patients with pulmonary affections or with kidney pathology. Spinal anæsthesia carries out Crile's anoci-association idea completely. In addition to these special indications we believe that spinal anæsthesia is the

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anæsthetic of choice in most urological and gynecological surgery, in amputations of the lower extremities, and in all acute abdominal conditions, except when some contra-indication is present.

The contra-indications may be stated as: (1) All operations above the diaphragm. (2) Operations on patients with hypotension (below 95 systolic). (3) Surgery on patients with high systolic and with relatively low diastolic blood-pressure or on patients with decompensated hearts. (4) Cerebrospinal infection.

In surgery on patients with kidney pathology it seems to us spinal is expressly indicated. Saklad has proven by comparative blood chemistry tests

OPERATION	AMT. OF ANESTHETIC	DURATION	SUPPLEMENTAL ANESTHETIC
SPINOCAINE			
Perineorrhaphy	2 cc.	To knees only	Nitrous oxide & ether
Appendectomy	2 cc.	$\frac{1}{2}$ hour	Infiltration for skin
NUPERCAINE			
Cholecystectomy	2 cc.	6- $\frac{1}{2}$ hr.	Novocaine infiltration for incision
Amputation of leg	2 cc.	8 hours	Ethylene to start with
Amputation of leg		2- hrs.	Novocaine infiltration for incision

Spinocone in 2 of 12 cases had to be supplemented by some other anæsthetic; 1 because anæsthesia reached to knees only and 1 because of re-turn of sensation in 30 minutes.

Nupercaine in 3 of 4 cases required supplemental anæsthetic to make initial incision.

TABLE III.—Cases in which spinal anæsthesia was supplemented by some other anæsthesia.

on patients under ether and under spinal anæsthesia that the (1) blood urea and blood sugar were much higher with ether, and (2) that the CO<sub>2</sub> combining power of blood plasma was lower when ether was used. In other words, these tests show that a patient under spinal anæsthesia has a lesser protein retention, a better carbohydrate metabolism, and a lesser tendency to acidosis than under ether anæsthesia. The better carbohydrate metabolism and the lesser tendency to acidosis explains why spinal is safer than ether in surgery on patients with diabetes.

*Advantages and Disadvantages.*—The advantages to the patient of spinal over general anæsthesia are (1) less shock; (2) less strain on eliminating organs (kidneys); and (3) fewer and less severe post-operative complications.

The advantages to the surgeon are (1) complete relaxation of the abdominal muscles. This seems to us to be of extreme importance. Such relaxation allows for an easy and complete exploration of the abdominal cavity and for an easy closure of the abdominal wound. (2) There is less disturbance during the operation by the patient's attempts to vomit or strain. Although the patient may attempt to vomit, the abdominal viscera do not bulge into the wound because of the complete relaxation of the abdominal muscles.

The principal disadvantage is the shortness of the anaesthesia, making it at times necessary to use a supplemental anaesthetic such as gas or local infiltration. In our series of 220 cases, 28 (12 per cent.) required supplemental anaesthesia as shown in Tables III and IV.

In three of these cases supplemental anaesthesia would not have been neces-

OPERATION	AMT. OF ANAESTHESIA	DURATION	SUPPLEMENTAL ANAESTHESIA
Herniotomy	100 mg.-2 cc.	1 hour	Novocaine infiltration of skin
Hysterectomy	150 mg.-2 cc.	1- hour	Gas
Appendectomy	150 mg.-2 cc.B	55 minutes	Alkoform for closing
Appendectomy	150 mg.-2 cc.B	No anaesthesia	Spinal repeated
Bilateral herniotomy	150 mg.-2 cc.B	1st.* 2nd c k	
Bilateral herniotomy	150 mg.-2 cc.	2- hours	Local infiltration
Bilateral herniotomy	200 mg.-2½ cc.	1½ hours	Local infiltration
Exploration of common duct	200 mg.-3 cc.B	1½ hours	Gas for closing
Appendectomy	150 mg.-2 cc.	1½ hours	Novocaine infiltration of skin
Cholecystectomy	150 mg.-3 cc.	1 hour	Ethylene and ether
Hemorrhoidectomy	100 mg.-1 cc.	20 minutes	Nitrous oxide
Appendectomy	150 mg.-2 cc.	25 minutes	Ethylene
Appendectomy	100 mg.-2 cc.	½ hour	Ethylene
Appendectomy	150 mg.-2 cc.	1½ hour	Novocaine infiltration to close
Appendectomy	150 mg.-2 cc.	1 hour, 20 min.	Ethylene
Appendectomy	100 mg.-2 cc.	1 hour	Ethylene
Cholecystectomy	200 mg.-3 cc.B	1½ hours	Ethylene
Herniotomy	150 mg.-2 cc.B	1 hour	Ethylene
Herniotomy	150 mg.-2 cc.	1 hour	Ethylene
Herniotomy (bilateral)	150 mg.-2 cc.	1½ hours	Ethylene
Appendectomy	150 mg.-2 cc.	1½ hours	Ethylene
Cholecystectomy	200 mg.-3 cc.B	½ hour	Ethylene
Repair of laceration of leg	50mg.-1 cc.	1 hour, 10 min.	Novocaine infiltration
Cholecystectomy	200 mg.-3 cc.	1½ hours	Ether

\* In one case of Novocaine crystals there was no anaesthesia, so the injection was repeated with perfect results.

TABLE IV.—Cases in which spinal anaesthesia was supplemented by other anaesthesia.

sary had we waited a few minutes longer before starting the operation. (See Table III.) These were cases in which nupercaine was used and the operation was started before its effect was complete. This solution requires a longer time to produce anaesthesia than novocaine, and in these cases a local injection was made for the initial incision. Two of the twelve cases in which spinocaine was used required a supplemental anaesthetic, and twenty-three of the 204 cases in which novocaine crystals were used required supplemental anaesthesia for closure. (See Table IV.)

**Complications.**—Careful attention has been given to complications and post-operative developments in this series and the percentages are given in Table V.

Headache has frequently been mentioned in the literature as a post-operative development in spinal anaesthesia. The origin of it still seems to be

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obscure. By some it is supposed to be due to meningismus, while others believe it is due to the loss of spinal fluid. It has not been a very troublesome complication in our patients, as only three patients had headache up to the second day and three others to the third day. 8.5 per cent. of the total series complained of headache at some time.

Four patients required catheterization for two days, two for three days, and one up to the fifth day. 15 per cent. in all required some catheterization. The necessity for catheterizations the first day is probably due to the para-sympathetic's unopposed action on the bladder sphincter.

It is interesting to note that 7 per cent. of the series had a bowel movement the first day without an enema. This also is probably due to the unopposed action of the para-sympathetics.

Six of our patients died at intervals of from five hours to nine days follow-

POST-OPERATIVE DEVELOPMENTS	
Headache	8.5 percent
Nausea	34. "
Vomiting	17. "
Distention	29. "
Catheterized	15. "
Bowels moved (1st day) without enema	7. "

TABLE V.—Note the fairly low per cent. of those in whom the distension was present and the per cent. having voluntary bowel movement the first day.

ing the completion of the operation. We do not believe the anæsthetic to be responsible for any of these deaths. A short summary of each case is given in the following:

### FATALITIES

CASE I was a male, twenty-one years of age, on whom an exploratory laparotomy was performed. The pre-operative diagnosis was hemolytic jaundice with an enlarged spleen. The post-operative diagnosis was thrombophlebitis of the portal and the splenic vein with liver abscesses. He was given 200 milligrams of novocaine crystals in 3 cubic centimetres of spinal fluid with barbotage. His systolic blood-pressure ranged from 130 to 100, and his diastolic from 82 to 54. His pulse rate varied from 118 to 78 per minute. He died on the eighth post-operative day of terminal pneumonia.

CASE II was a male, sixty-nine years of age, who developed gas gangrene following an amputation for arteriosclerotic gangrene. He was given 150 milligrams of novocaine crystals in 2 cubic centimetres of spinal fluid. His systolic blood-pressure varied from 184 to 98, and his diastolic from 120 to 76. His pulse rate was 88 to 78 per minute. He died of toxæmia on the fourth post-operative day.

CASE III was a male, fifty-five years of age, on whom a pyloroplasty had been performed for a perforated duodenal ulcer. He was given 200 milligrams of novocaine crystals in 3 cubic centimetres of spinal fluid with barbotage. His systolic blood-pressure



ranged from 112 to 38, and his diastolic from 80 to 0. His pulse rate was 140 to imperceptible. He became cyanotic and complained of air-hunger. The table was lowered in extreme Trendelenburg and pure oxygen was administered. An ampoule of coramine was given hypodermically and 1000 cubic centimetres of normal saline intravenously. No ephedrine or adrenalin was used for the drop in blood-pressure. The cyanosis lasted about ten minutes. This was the most extreme drop of the entire series; in fact, it was the only case in which the systolic pressure went below 50 millimetres of mercury. He died of bronchopneumonia on the ninth post-operative day.

CASE IV was a male, sixty-five years of age, on whom about half the stomach was resected for carcinoma. He also had tertiary syphilis and generalized arteriosclerosis. He was given 175 milligrams of novocaine crystals dissolved in 3 cubic centimetres of spinal fluid with barbotage. His systolic blood-pressure ranged from 98 to 78, and his diastolic from 74 to 54. He died on the second post-operative day of bronchopneumonia.

CASE V was a male, forty-nine years of age, on whom a herniotomy for strangulated hernia was performed. The patient was moribund, having had the strangulation for five days before entering the hospital. He was given 200 milligrams of novocaine crystals dissolved in 2 cubic centimetres of spinal fluid. His systolic blood-pressure ranged from 116 to 50, and his diastolic from 72 to 20. His pulse rate was extremely rapid all through the operation. No attempt was made to resect the bowel but the gangrenous loop was drawn out through a separate, higher incision and left to be opened at a later time. He died five hours after the operation from effects of toxæmia.

CASE VI was a male, sixty-six years of age, who developed gas gangrene in a burn on his leg. An amputation was performed. He was given 150 milligrams of novocaine crystals dissolved in 2 cubic centimetres of spinal fluid. His systolic blood-pressure ranged from 130 to 122, and his diastolic from 90 to 74. His pulse rate was 120 to 130. He died on the eighth post-operative day following extension of process into the muscles of the abdomen.

In all these cases the anæsthesia was satisfactory, and, as has been said above, in none could the death be attributed to the anæsthetic.

*Facts Concerning Skin Temperatures of Legs and Feet During Spinal Anæsthesia.*—In order to determine the effect of spinal anæsthesia on the temperature of skin of the feet and legs, eleven cases were studied. These were patients with no circulatory derangement. The skin temperature over the instep of the right foot was taken before the spinal injection and again after anæsthesia developed. Table VI shows the results of these tests.

The temperature was elevated some in all cases following the spinal injection. Thinking this test would be of value to determine the advisability of sympathetic gangliectomy in cases of Raynaud's and Burger's diseases, it was used on one case of Raynaud's and the result is shown in Graph VI.

The skin temperatures of the feet rose 6° and 4° after the injection. To test the reliability, the typhoid vaccine test was applied to the same patient and the same result was obtained. This patient was operated upon with excellent results.

#### REPORT OF QUESTIONNAIRE

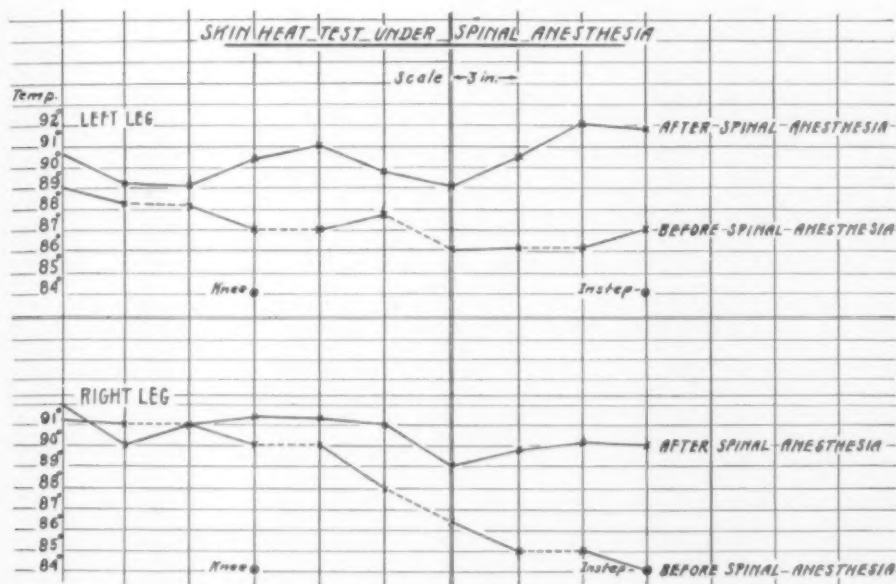
In 1927, a questionnaire was sent out by Dr. Edwin Stanton, of Schenectady, New York, to several hundred American surgeons with the object of

# SPINAL ANÆSTHESIA

## SKIN TEMPERATURES ON 11 CASES WITH NO CIRCULATORY DERANGEMENT

AGE	TEMPERATURE BEFORE SPINAL INJECTION	TEMPERATURE AFTER SPINAL INJECTION
30	88° F.	92° F.
14	85° F.	89° F.
58	85° F.	92° F.
59	94° F.	94.5° F.
48	85° F.	92° F.
16	87.5° F.	90° F.
37	83° F.	86° F.
48	87° F.	90° F.
69	84° F.	86° F.
14	91° F.	93.5° F.
58	90° F.	90.5° F.

TABLE VI.—This shows that the skin temperature rose in every patient under spinal anæsthesia. The degree of rise shows no relationship to age or condition of vessels in this series.



GRAPH VI.—This graph shows the variation of skin temperatures at various levels before spinal injection and after anæsthesia developed in a case of Raynaud's disease. Temperatures were taken every three inches from the ankle to above the knee.

CRANMER AND HENRIKSON

determining the anæsthetic most frequently used in good-risk and poor-risk cases and also to determine the extent to which spinal anæsthesia was being used at that time. There were 419 out of 622 surgeons (66 per cent.) who stated definitely that they did *not* use spinal anæsthesia. There were 203 (34 per cent.) who stated that they were using it in some types of cases.

Answers to Questions 1 & 2	GOOD RISK CASES						POOR RISK CASES					
	Ether	W20 +0	Ethylene	Local	Spinal	Others	Ether	W20 +0	Ethylene	Local	Spinal	Others
ATLANTA	1	1 2+	3	0	4 2+		0	2+	1	5	4 2+	
BALTIMORE	5	1 5+	1	0	3 1	Lavertin " + E	0	1 2+	5	3	4 1+	
BOSTON	12	1 4+	1	0	9 2+		0	2-	2	6	13- 1+	
CHICAGO	9	9+	3	0	5		2	1+	7	8	10	
CLEVELAND	3	4 6+	0	0	5		2	6 1+	0	2	5	
DALLAS	1	0	1	0	2		0	0	0	0	4	
DENVER	11	1+	3	0	3 1+		3	2	2	4	5 2+	
DETROIT	8	1	2	0	14 2+		0	2	2	6	13 2+	
KANSAS CITY	7 2+	1 2+	0	0	2		1	2 4+	1	3	2 1+	
LOS ANGELES	6	7+	3	0	8 1+		3	3+	1	7	11 5+	
MILWAUKEE	1	0	1	0	3		0	0	0	4	1	
NEW ORLEANS	2 1+	0	2 2+	0	0		0	0	2	1+	3 2+	
NEW YORK	6	5+	2	0	7 1+		2	0	0	8	13 1+	
OMAHA	1	1+	0	0	7 1+		1	0	0	1+	8	
PHILADELPHIA	2	1	0	0	4		0	1	1	2	3	
PITTSBURGH	2	1+	0	0	3		1	0	0	2	3	
PORTLAND	7	3+	3	0	2		0	4+	3	2	4 2+	
SAN FRANCISCO	2	1 4+	0	0	9 6+		0	6+	0	4	12	
SEATTLE	5	1+	0	0	2		2	0	1+	3	2 2+	
ST. LOUIS	5 1+	1 3+	5	1	3		0	2 3+	0	8	6	
Total	96 4+	13 54+	30 18+	1	95 19+		17 1+	18 29+	27 6+	77 6+	126 23+	
Percentage	30.3	20.3	14.5	0.3	34.5		5.4	14.2	10.0	25.1	45.1	

TABLE VII.—On the left is a tabulation of the replies to question No. 1: "What anæsthetic do you use as a rule in laparotomies in the average run of good risk cases?" On the right are tabulated the replies to question No. 2: "What anæsthetic do you use in laparotomies comprising the poor risk group?" The plus sign after the figure indicates that some additional anæsthetic is used in certain cases.

Those who were using it were, for the most part, using it in prostatectomies, amputations of the lower extremities, pelvic cases, and in diabetics. Twenty-one of them stated they reserved it for "poor-risk" cases.

Since then, spinal has become more frequently used and articles on the subject have appeared with increasing frequency in the literature. Thinking it would be of interest to determine the extent of the swing of the pendulum

# SPINAL ANÆSTHESIA

in favor of spinal anæsthesia, a similar questionnaire has been sent out to 500 members of the American College of Surgeons. The names of the surgeons were picked at random from the bulletin of the American College of Surgeons, care being taken not to pick those specializing in diseases of the eye, ear, nose and throat. The questionnaire was sent only to surgeons practising in twenty large cities of the United States covering every section of the country.

Question No. 1 was: *What anæsthetic do you use as a rule in laparotomies in the average run of good-risk cases?*

Question No. 2: *What anæsthetic do you use in laparotomies in cases comprising the poor-risk group?*

Answers to Question #3							Answers to Question #4		
	SPINAL		CLASS OF CASES				INCREASE	DECREASE	NO CHANGE
	NO	YES	GOOD	POOR	OCCASION-ALLY	BOTH			
ATLANTA	3	10	7	6	0	3	13	0	
BALTIMORE	9	9	3	5	3	2	11	1	5
BOSTON	4	26	11	16	5	6	28	1	1
CHICAGO	17	19	5	10	7	3	26	1	9
CLEVELAND	5	13	5	5	7	4	16	2	2
DALLAS	0	4	2	4	0	2	4	0	0
DENVER	0	18	4	7	10	3	17	0	1
DETROIT	2	24	16	16	3	11	22	2	2
KANSAS CITY	5	8	2	3	5	2	9	0	4
LOS ANGELES	5	22	9	16	5	8	23	1	3
MILWAUKEE	1	4	3	1	1	1	4	0	1
NEW ORLEANS	0	8	0	5	3	0	7	0	1
NEW YORK	0	25	10	14	7	6	23	2	0
OMAHA	0	10	8	8	1	7	10	0	0
PHILADELPHIA	1	7	4	3	2	2	7	0	1
PITTSBURGH	1	5	3	3	2	3	6	0	0
PORTLAND	7	9	2	5	3	1	10	4	2
SAN FRANCISCO	1	21	15	12	3	9	19	0	3
SEATTLE	2	5	2	4	2	3	5	0	2
ST. LOUIS	6	13	3	6	6	2	15	1	3
Total	69	261	114	149	75	78	275	15	40
Percentage	21%	79%	34.5%	45.1%	22.7%	23.6%	83.3%	4.5%	12.2%

TABLE VIII.—On the left are tabulated the replies to question No. 3: "Do you use spinal anæsthesia, and if so, in what class of cases do you use it?" On the right are tabulated the replies to question No. 4: "Has the opinion in your section of the country concerning spinal anæsthesia changed in the last few years?"

Question No. 3: *Do you use spinal anæsthesia and in what class of cases do you use it?*

Question No. 4: *Has the opinion in your section of the country concerning spinal anæsthesia changed in the last few years?*

The results of the questionnaire have been tabulated as shown in Tables VII and VIII.

The tabulation shows that there were 352 replies to the 500 letters (70 per cent.). Twenty-two of these stated that they had retired because of poor health or for other reasons. This left 330 replies. Table VII shows the answers to questions 1 and 2 reported by cities, and is self-explanatory. Table VIII shows the answers to questions 3 and 4.

Nine of 18 answering from Baltimore do not use spinal. This is the lowest percentage of all the cities. Seven of the 18 use avertin in a certain percentage of cases. Richard Te Linde states that 3 deaths in 15 spinal anesthetics in 1929 caused the surgeons in Baltimore to look upon it with disfavor, and he also states that, except for the Brady Urological Institute, not much spinal is used at Johns Hopkins. Other Baltimore surgeons, including Shipley, Toulson, and Blake, do use it, some of them being very enthusiastic over it.

In Atlanta, Georgia, most of the surgeons answering the questionnaire use it to some extent. Dr. George W. Fuller uses it in practically all surgery below the diaphragm in both private and service cases. He states that some of the hospitals at Atlanta are using it in about three-fourths of the laparotomies.

In Boston, a large majority use spinal anesthesia. Several volunteered the statement that novocaine crystals are being used almost to the exclusion of other preparations, such as Pitkin's solution, *etc.* Dr. A. R. Kingston uses it below the diaphragm in nearly 90 per cent. of his cases. He is one of several throughout the United States who state that Cæsarian section is a contra-indication to spinal anesthesia. He states that he has, however, done Cæsarian operations under spinal without the slightest trouble, and is of the opinion that if it is used at all it should be used only in small dosage. Dr. J. S. White, of the Massachusetts General Hospital, states that because the incidence of pulmonary complications is as great under spinal as under ether, he is using it only in amputations of the leg or in perineal operations or where a low spinal can be used.

The Chicago surgeons, as a whole, are rather conservative in the use of spinal anesthesia. Jonnesco's first case, many years ago, at the Cook County Hospital demonstration, died, and as a result spinal anesthesia has gained favor slowly. Dr. James T. Case states that the popularity is gradually increasing now, however. He has used it in 1,700 patients, most of whom were gynecological cases. Ethylene, in both good- and poor-risk cases, is being used more in Chicago than in any other city of the country. Doctor Culbertsen, of Chicago, thinks that in the more difficult abdominal cases, with adhesions, *etc.*, nothing gives the excellent intestinal relaxation that is present with spinal anesthesia.

Few of the Cleveland surgeons use spinal as the anesthetic of choice. Professor Cutler, of the Western Reserve University, employs it where the renal function is poor and in diabetics. He also uses it in prostatectomies and amputations of the leg. William Lower, of the Cleveland Clinic, uses it in all his urological cases unless there is some contra-indication.

Detroit surgeons are more enthusiastic concerning spinal than surgeons of any other large city, with the possible exception of New York and San Francisco. Clark D. Brooks has used it in 4,000 cases and uses novocaine crystals only.

In Philadelphia, the men doing a large volume of surgery are generally enthusiastic concerning spinal. Dr. Wayne Babcock, one of the pioneers in



## SPINAL ANÆSTHESIA

spinal anæsthesia, uses novocaine and stovaine with alcohol to lighten the specific gravity. Doctor Deaver has used it in about 5,000 cases and prefers Pitkin's solution.

Dr. J. C. Negely, of Los Angeles, is one of the pioneers in spinal anæsthesia on the coast, having reported 5,500 cases up to 1925. He uses it in all classes of cases except when the systolic blood-pressure is at or below 100. Los Angeles surgeons generally favor spinal anæsthesia.

In New Orleans, Doctor Matas has been a pioneer in the use of spinal anæsthesia. He states that he uses it in all operations on the extremities, in genito-urinary and gynecological cases, and as a rule in all operations below the waist, including those for intestinal obstruction. He also states that spinal anæsthesia's popularity is still increasing in New Orleans. Doctor Danna, of New Orleans, has used spinal anæsthesia for twenty-eight years and is using it more and more, especially in the last three or four years. Dr. Anton Ochsner, of that city, is using it especially in his poor-risk cases and in laparotomies where relaxation is especially desired.

In New York City spinal is used more than any other anæsthetic, according to returns from the questionnaire. Neocaine is used more extensively there than other preparations. Gaston Labat, of New York, has long been an advocate of spinal anæsthesia, and has done much to bring it into national favor.

The surgeons of Omaha are, almost to a man, in favor of it and many use it in both good- and poor-risk cases.

Spinal anæsthetics are used conservatively in Portland, Oregon. Drs. Robert Coffey and William Holden state that they use it cautiously and usually in cases where there is some pulmonary risk.

San Francisco surgeons as a rule are extremely partial to spinal anæsthesia. Nine of the 22 men answering the questionnaire state that they use it in both good- and poor-risk cases. One states that he uses it in 95 per cent. of his laparotomies.

Dr. E. A. Graham, of Washington University School of Medicine, states that although he is not using spinal in many cases, other members of the department use it extensively in gynecological and genito-urinary and lower extremity cases. He also states that more spinal is being used in St. Louis than formerly.

Some of the unsolicited facts and expressions obtained from the questionnaire are:

(1) There were 26 of the 330 surgeons who expressed themselves as favoring novocaine crystals dissolved in spinal fluid in preference to other solutions.

(2) There were 14 who expressed themselves as favoring Pitkin's solution of spinocaine.

(3) There were 3 who expressed themselves as favoring neocaine.

(4) There were 10 who volunteered the statement that Cæsarian section was a contra-indication for spinal anæsthesia.

- (5) Urologists, as a group, seem most enthusiastic over spinal anæsthesia.
- (6) Intestinal obstruction was the condition most frequently mentioned in which spinal was the anæsthetic of choice.
- (7) There were 275 of the 330 surgeons who stated that spinal anæsthesia is increasing in popularity in their section of the country, and but 15 state that it is decreasing.
- (8) There were 40 who stated that they had observed no change in the number of surgeons using this type of anæsthesia.

#### REFERENCES

- <sup>1</sup> Babcock, W. W.: Textbook of Surgery. W. B. Saunders Co., Philadelphia, 1928.
- <sup>2</sup> Campbell, Meredith F.: Spinal Anæsthesia. Jour. of Urol., vol. xxiv, pp. 279-301, September, 1930.
- <sup>3</sup> Chute, Arthur L.: The Use of Spinal Anæsthesia in Urology. J. A. M. A., pp. 88-91, January, 1931.
- <sup>4</sup> Evans, C. H.: Spinal Anæsthesia. Paul B. Hoeber, New York, 1929.
- <sup>5</sup> Johnson, V. E.: Spinal Anæsthesia. Amer. Jour. Surg., vol. xi, pp. 478-484, March, 1931.
- <sup>6</sup> Koster, H.: Spinal Anæsthesia for the Head, Neck and Thorax; Its Relation to Respiratory Paralysis. Surg., Gynec. and Obstet., vol. xlv, pp. 617-630, 1929.
- <sup>7</sup> Labat, Gaston: The Trend of Subarachnoid Block. Surg. Clin. of North America, vol. x, p. 671, 1930.
- <sup>8</sup> McKittrick, Leland S., *et al.*: Spinal Anæsthesia in Abdominal Surgery. Surg., Gynec. and Obstet., pp. 898-909, April, 1931.
- <sup>9</sup> Pitkin, G. P.: Controllable Spinal Anæsthesia. Surg., Gynec. and Obstet., vol. xlv, pp. 713-726, 1928.
- <sup>10</sup> Rankin, Fred W., and McCuskey, Charles F.: Spinal Anæsthesia in Surgical Procedures on the Colon. Anesthesia and Analgesia, vol. ix, pp. 44-46, 1930.
- <sup>11</sup> Saklad, Meyer: Studies in Spinal Anæsthesia. Amer. Jour. Surg., vol. xi, pp. 452-460, March, 1931.

## SPINAL ANÆSTHESIA ON A GENERAL SURGICAL SERVICE \*

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DURING the past three years four hundred spinal anæsthesias have been administered on the Second Surgical Service (Cornell) of Bellevue Hospital. A complete record of each case was kept during the patient's course in the hospital to make possible an unbiased decision as to its preference over general anæsthesia, its indications, and contra-indications.

The method used has been the dissolving of 40 to 170 milligrams of novocaine crystals in 2 to 20 cubic centimetres of spinal fluid, depending upon the level of anæsthesia required. Only the third and fourth lumbar interspaces were used with the exception of two thoracoplasty cases where a higher level was attempted. Spinocaine was used for a period when novocaine crystals were not available in the hospital.

An analysis of the records was made with the following factors in mind: 1, Mortality; 2, post-operative complications; 3, Disturbing symptoms directly due to spinal anæsthesia, A, Low blood-pressure, B, Headaches, C, Psychic disturbances; 4, Failures or semi-failures of anæsthesia; 5, uniformity or expectancy of level and duration of anæsthesia under identical conditions; 6, Indications or contra-indications for spinal anæsthesia.

1 and 2.—Only those cases occurring between the months of November and May of both respective years were included in the statistical series. The remaining 180 cases not tabulated were between the months of May and October. There was no pneumonia incidence. During the winter of 1928-1929 pneumonia and post-operative pneumonia were extremely prevalent in New York City. During the following winter, 1929-1930, its incidence was very low, in fact less than usual.

The statistics for the first winter, 1928-1929, show a mortality of 13.3 per cent. and a pneumonia incidence of 9.16 per cent. with six deaths. 11.7 per cent. of the deaths were abdominal and chest operations.

The winter of 1929-1930 showed a mortality of 5 per cent. and a pneumonia incidence of 3 per cent. However, only five cases of the series were abdominal and chest operations, as against thirty-four for the previous year.

A control series in both years receiving general anæsthesia showed approximately the same pneumonia incidence but a lower mortality.

Only two deaths could have been due directly to spinal anæsthesia; one a cholecystectomy who died seven hours following operation with apparent respiratory failure, and one a thoracoplasty who died fourteen hours following operation from the same cause.

\* Prepared for Graduate Fortnight. New York, Academy of Medicine, 1928-1929.

3.—20 per cent. of the first series and 16 per cent. of the second series had disturbing symptoms directly due to the spinal anæsthesia while on the operating table. The symptoms varied from slight shock with slight mental discomfort to severe shock, nausea and vomiting, and extreme mental disturbance and discomfort. This occurred with the patient's head both level and lowered and with manometer readings of spinal fluid pressure taken and the injection made at a uniform pressure—10 millimetres of mercury obtained by the amount of spinal fluid withdrawn. An anæsthetist was needed just as much with spinal anæsthesia as with general anæsthesia.

4.—In 10 per cent. of the first series and in 7 per cent. of the second series the spinal anæsthesia failed completely or had to be supplemented with general anæsthesia.

5.—8 per cent. of the first series and 5 per cent. of the second had severe headaches for the first few days following operation with extreme discomfort.

6.—Although every method which has been suggested, including the use of spinocaine, was used, no uniformity of level or duration of analgesia was ever obtained. One patient who received 170 milligrams dissolved in 20 cubic centimetres of spinal fluid had complete analgesia of the entire body and died seven hours following the operation from shock and respiratory failure. The next patient receiving the identical amount in the same manner had to have general anæsthesia before the peritoneum could be opened, his analgesia lasting about fifteen minutes. Analgesia varied from none at all to one hour and forty-five minutes under identical technic. This variable factor could not be corrected.

Traumatic cases already in shock were never given a spinal anæsthesia after the first two cases due to the fact that it deepened their shock if an immediate operation had to be done or caused it to recur if operation was postponed until it had subsided.

The conclusions that can be drawn from this series of cases are the following.

1. Spinal anæsthesia, 40 to 120 milligrams of novocaine, in the fourth lumbar vertebral space for lower extremity, rectal, perineal, and hernia operations is safe and satisfactory. The post-operative complications are as numerous as with general anæsthesia. There is also a certain percentage of failures.

2. Spinal anæsthesia, 120 to 170 milligrams of novocaine, dissolved in 2 to 20 cubic centimetres of spinal fluid and injected in a higher level for abdominal and chest operations is not safe. The post-operative complications are as numerous as in general anæsthesia. The shallow respiratory excursions would accentuate rather than lessen the possibility of post-operative pneumonia. The only post-operative lung abscess which has occurred on the service was a gastric resection under spinal anæsthesia supplemented by nitrous oxide for the last half hour of the operation. Those patients who go into shock with resultant lowered tissue resistance are more susceptible to infection. The technical danger of injuring the cord at a higher level is always present.

## SPINAL ANÆSTHESIA

3. The poor surgical risk, with constitutional disease, damaged heart vessels or kidneys, is a still poorer risk with spinal anæsthesia.

4. Spinal anæsthesia is definitely contra-indicated in the patient already in traumatic shock or soon after the subsidence of his shock.

5. Spinal anæsthesia is strongly indicated in the elderly patient suffering from an incarcerated hernia, for two patients aged seventy-eight and eighty had a spontaneous reduction within fifteen minutes following the injection when all other methods failed.

6. It is by far the analgesic of choice in all fractures of the lower extremity and pelvis not in shock necessitating the use of the fracture table and application of plaster.

7. It is strongly indicated in acute intestinal obstruction for those not mechanical will be relieved and those mechanical will make the operative procedure easier.

8. In selected types of patients it has proven very satisfactory in pelvic operations.

TABLE OF OPERATIONS

*In Which Spinal Anæsthesia Was Used*

	1928-1929	1929-1930
1. Rectal .....	24	48
2. Hernia (repair) .....	32	35
3. Lower extremity .....	26	13
A. Compound fractures and fractures		
B. Infections—cellulitis—osteomyelitis		
C. Amputations		
4. Cholecystectomy .....	4	0
5. Abdominal hernia .....	3	0
6. Appendectomy .....	7	1
7. Intestinal obstruction .....	5	1
8. Thoracoplasty .....	3	0
9. Gastro-enterostomy .....	5	1
10. Strangulated hernia .....	2	0
11. Exploratory laparotomy .....	2	1
12. Gastric resection .....	2	0
13. Gastrostomy .....	2	0
14. Tracheloectomy .....	1	0
15. Inoperable carcinoma .....	1	0
16. Carcinoma of cæcum .....	1	0
	120	100

NOTE.—Because of the high incidence of post-operative pneumonia and the uncertainty of duration of an anæsthesia in the first series, spinal anæsthesia was discontinued in upper abdominal operations.



## SPINAL ANÆSTHESIA WITH NUPERCALINE AND PROCAINE

A COMPARATIVE STUDY

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ALTHOUGH we have been using procaine spinal anæsthesia extensively and successfully in urologic surgery for more than fifteen years, we have recently been trying nupercaine following a preliminary report of its use by Keyes and McLellan.\*

We were impressed with the reports of the German investigators concerning this compound, derived from quinolin, particularly in regard to the intensity of anæsthesia. It is to be noted, however, that not all the reports showed uniformly successful results; also where failures were recorded, faulty technic was generally blamed as the cause of failure.

Some have found that a 1-2000 solution for infiltration purposes, despite statements to the contrary, does not equal the anæsthetic activity of 0.5 per cent. procaine. Suffice it to say, that, for infiltration purposes, in a limited series of cases, we have found 1 per cent. procaine more satisfactory and have given up the use of nupercaine by this route.

Nupercaine has been used for spinal, caudal, paravertebral and infiltration anæsthesia, also for topical application to mucous membranes.

We have been impressed with the statement that the substance, prepared by Karl Miescher, is five times more toxic than cocaine and having ten times the activity of the latter drug. However, subsequent work on animals, together with its clinical use, would indicate that the margin of safety in its use, as prescribed, is much greater than the figures given.

With the maximum dose of cocaine fixed at 50 milligrams, the maximum dose for nupercaine would, therefore, be 10 milligrams. This latter dose is contained in 2 cubic centimetres of 0.5 per cent. solution (used by us in ampoule form for spinal anæsthesia). This dose would also be contained in 10 cubic centimetres of 1-1000 solution and 20 cubic centimetres of 1-2000 solution.

It is to be noted that solutions in salt solution can be sterilized at 221 degrees F. for one half hour without impairing their activity. The sodium chloride must, however, contain no soda or sodium bicarbonate, and, when kept, should be contained in alkali-free glass. It has been recommended that five drops of dilute HCl. be added to containers of solution of 1-1000 or 1-2000.

We have not seen the hyperæmic condition of the skin or possible skin necrosis said to have followed its use. It has been suggested that a few drops of adrenalin be added to the solution before injection to correct this effect.

\* Keyes, E. L., and McLellan, A. M.: *Am. J. Surg.*, vol. ix, p. 1, July, 1930.

## SPINAL ANÆSTHESIA

In the following series of cases, exactly the same technic of spinal injection was used in all, the same that we have been using on the service for many years. Each patient received morphine and scopolamine, thirty to forty-five minutes before operation, and  $\frac{3}{4}$  grain of ephedrine just prior to spinal injection. A No. 20-gauge needle was usually passed through the second or third lumbar interspace, and, in some kidney cases, in the first lumbar interspace; always with the same "snap" of the dura and withdrawing the spinal fluid slowly into a 3 cubic centimetre syringe and carefully mixing.

### ANALYSIS OF 50 CONSECUTIVE NUPERCARINE SPINAL ANÆSTHESIA CASES

Successful—41 (82 per cent.)

Failures—9 (18 per cent.)

#### *Time of Induction of Anæsthesia (Excluding 8 Failures)*

5 minutes — 18 cases    35 cases had good anæsthesia within 10 minutes.  
 10 minutes — 17 cases  
 15 minutes — 4 cases  
 20 minutes — 1 case  
 25 minutes — 1 case    Anæsthesia in these last 3 cases lasted only  $1\frac{1}{2}$  hours.  
 35 minutes — 1 case

#### *Duration of Anæsthesia (Excluding 6 Failures)*

1 hour — 2 cases (only 1 cubic centimetre was used, or  $\frac{1}{2}$  dose)  
 $1\frac{1}{2}$  hours — 3 cases  
 2 hours — 11 cases  
 $2\frac{1}{2}$  hours — 10 cases  
 3 hours — 6 cases  
 $3\frac{1}{4}$  hours — 1 case  
 4 hours — 1 case  
 Unknown—8 cases (more than 2 hours)

#### *Length of Operating Time (Excluding 7 Failures)*

20 minutes — 6 cases	65 minutes — 3 cases
30 minutes — 9 cases	80 minutes — 1 case
45 minutes — 17 cases	85 minutes — 1 case
60 minutes — 5 cases	1 hour 40 min. — 1 case

#### *Type of Operation*

Kidney—16 cases, with 4 failures.  
 Bladder—11 cases, with no failures.  
 Prostate—9 cases, with no failures.  
 External genitalia—11 cases, with 3 failures.  
 Transplantation of ureters (Coffey method)—3 cases, with 2 failures.

#### *Headache*

Sixteen cases or 32 per cent. had a moderately severe or a severe headache, all requiring codeine or coal tar preparation.

#### *Duration of Headache*

Lasting 2 to 6 hours — 2 cases	Lasting 24 hours — 2 cases
Lasting 6 to 9 hours — 2 cases	Lasting 2 days — 3 cases
Lasting 12 hours — 6 cases	Lasting 3 days — 1 case

Seven cases had moderate degree of nausea and vomiting. This has not been troublesome.

## HARRIS AND GOLDBERG

### ANALYSIS OF 50 CONSECUTIVE PROCAINE SPINAL ANÆSTHESIA CASES

1—Failures, total and partial—2 cases or 4 per cent.

Insufficient duration anæsthesia—4 cases or 8 per cent.

#### 2—Type of operation

Kidney—9 cases, with no failures.

Bladder—14 cases (with two imperfect anæsthesia).

Prostate—19 cases (with two imperfect anæsthesia).

External genitalia—8 cases (with two imperfect anæsthesia).

3—"Puncture" headache rarely occurred in any of our procaine cases (including a previous large series).

4—The induction-time was definite, more rapid, but anæsthesia of much shorter duration than with nupercaine.

*Analysis of six imperfect procaine anæsthesia cases.* Failures. 1—Second-stage prostatectomy. Procaine 120 milligrams. After ten minutes, gas-oxygen anæsthesia was used. Operation lasted thirty-five minutes.

2—Cystotomy and fulguration of bladder carcinoma. Procaine 240 milligrams. Operation started five minutes after spinal injection. After waiting twenty minutes, gas-oxygen anæsthesia was used to complete operation and obtain relaxation. Blood pressure did not fall (120/60). Operating time, 55 minutes.

Insufficient duration of anæsthesia (procaine). 1—Bilateral hydrocele and varicocele. Procaine 120 milligrams. Induction-time five minutes with good anæsthesia. Operating time, thirty-five minutes. Morphine sulphate grains  $\frac{1}{4}$  given after thirty minutes as sensation began to return. No general anæsthesia used.

2—Resection of carcinoma of prostate (radiotherm knife). Procaine 120 milligrams. Induction-time, five minutes. Operating time, sixty-four minutes. Gas-oxygen anæsthesia used five minutes before completion of anæsthesia. (Anæsthesia lasted fifty-five minutes. Then blood pressure rose from 120 to 140 suddenly.)

3—Bilateral epididymotomy. Procaine 120 milligrams. Induction-time, five minutes. Blood pressure, 100/50 after five minutes; 135/90 after fifteen minutes; 120/70 after twenty-five minutes. Operating time, sixty minutes. Light gas-oxygen-ether was begun ten minutes after incision was made because patient was very uncomfortable and apprehensive. Usual pre-operative medication of morphine sulphate grs.  $\frac{1}{4}$ . Scopolamine grs.  $\frac{1}{200}$  had been given.

4—Cystotomy and resection of bladder carcinoma. Procaine 120 milligrams. Induction-time, five minutes. Operating time, seventy minutes. Pain felt after thirty-five minutes. Gas-oxygen given at end of forty minutes.

*Analysis of nupercaine failures.* Failures. 1—External urethrotomy. Waited twenty minutes. Gas-oxygen used. (Patient apprehensive.)

2—Nephrectomy. Waited ten minutes with no anæsthesia at the end of this time. General anæsthesia used.

3—Coffey ureteral transplantation. Waited forty minutes. General anæsthesia used.

4—Hydrocele. No anæsthesia after fifteen minutes. Light gas-oxygen used.

Partial failures (nupercaine). 1—Nephrectomy. Waited only eight minutes. Complained of pain. Supplemented by light gas-oxygen which was stopped ten minutes before end of operation. (Patient apprehensive.)

2—Nephrotomy. Waited twenty minutes. Patient complained of pain during operation. No supplementary anæsthesia given. (Apprehensive.) Second operation under 150 milligrams procaine (ureterotomy) with perfect anæsthesia.

3—Ureterotomy. Waited twenty minutes. Light gas-oxygen given.

4—Coffey ureteral transplantation. Waited twenty-five minutes. Light gas-oxygen used. Some anæsthesia present after three hours. Operation required two hours. (Patient very apprehensive.)

## SPINAL ANÆSTHESIA

5—Orchidopexy. Pressure-sensation felt throughout operation. Uncomfortable, but no general anæsthesia given.

Two cases given 1 cubic centimetre ( $\frac{1}{2}$  dose) of nupercaine, had anæsthesia for only one hour. These were the first two cases in the series when only half dose was used. Since then, we have been using 2 cubic centimetres routinely.

A case of Coffey ureteral transplantation. Complained of some pain in the last half hour. Operating time, two hours, ten minutes. No additional anæsthesia was given. A case of partial resection of kidney, with operation time of sixty-three minutes, complained of pain in last twenty minutes. No additional anæsthesia was necessary. (Had rather marked distention for forty-eight hours.) A one-stage prostatectomy case, died of paralytic ileus thirty-six hours following operation. Twenty-three minims of nupercaine were used. (Full dose thirty minims.) Anæsthesia lasted two and one-half hours. Death did not appear to have any relationship to spinal anæsthesia. A first-stage cystotomy operation, had good anæsthesia. At the second operation (prostatectomy) induction took twenty-four minutes and patient complained of some pain throughout, but no additional anæsthesia was given. (Crabtree perineal prostatectomy, forty-seven minutes' operating time.)

*Conclusions.*—(1) It is worthy of note that, where nupercaine anæsthesia was partial, the patients were notably apprehensive.

(2) In comparing the individual blood-pressure curves during operations, as many variations were found with nupercaine as were present with procaine.

(3) Hourly blood-pressure readings were taken following operation, but so little variation was found, that this was discontinued after six cases.

(4) For six to eight hours following operation the majority of patients having nupercaine were notably comfortable without narcotics. This was in contrast to the procaine cases.

(5) No death occurred which could be attributed to nupercaine injection.

(6) Induction time is slower with nupercaine in many cases than with procaine. It might be wise to inject the drug thirty to thirty-five minutes before the operation is begun.

(7) "Puncture" headache appears to be much more frequent with nupercaine than with procaine.

(8) We began by using 1 cubic centimetre 1-200 solution of nupercaine and gradually increased to 2 cubic centimetres, and now feel that the full dose is perfectly safe for routine use.

(9) In view of the variable results obtained in our first fifty cases, we believe that nupercaine for spinal use should be reserved for operations lasting over an hour, after which time the effects of procaine, in doses of 120 to 150 milligrams (doses we usually employ) may wear off.

(10) We have noted a peculiar persistence in some nupercaine cases of the sense of touch or contact, with obliteration of pain sense.

(11) A number of neurotic patients complained and worried over the persistence of paralysis of the legs, after operation, following nupercaine.

(12) Perhaps the ventral position would aid in effecting anæsthesia following injection. We have not tested it.

(13) The ideal to be reached is obliteration of pain sense without affection of the motor fibres. The use of small doses of either nupercaine or procaine

to exclude the motor fibres would appear to be impractical for major surgical operations.

(14) The action of nupercaine is definitely more variable and uncertain in our hands.

(15) We have not been disposed to try the method suggested of injecting a mixture of procaine and nupercaine.

(16) Nausea or vomiting has been exceptional and there was no evidence of frank toxic reaction on the part of any patient in this series.

(17) Continued investigation in spinal anaesthesia should now be carried on by the physiologist, pharmacologist and chemist working in conjunction with the clinician.



## SUTURING THE BONES OF THE FOREARM\*

BY ISADORE ZADEK, M.D.

OF NEW YORK, N. Y.

I AM presenting a method of bone suture especially applicable to the bones of the forearm which I have found to be effective, and which, so far as I know, is original. A review of the literature back as far as 1890 discloses no similar report.

The experience of others has, no doubt, been the same as mine; that is, that where open reduction has been indicated, one has been forced to put in non-absorbable material, either in the form of a Lane plate, or a wire, or he may have attempted to "notch" the bones in the hope that fixation would be sufficiently secure. This "notching" is open to the same objections that characterize the use of a single suture.

The third alternative has been that of putting in absorbable suture material, and the usual material has been kangaroo tendon.

Considering only the last method: After drilling the bone and reducing the fracture, and tying the suture, one has proceeded to attack the other bone, and my experience has been that, during the manipulation incidental to the reduction of the second bone, the suture in the first bone has become loosened and fixation has been insecure. The point has been raised as to whether or not it is necessary to do an open reduction on both bones of the forearm, the radius being larger and more important. From my experience I consider it desirable to treat both bones alike.

The particular technic used (Fig. 1) has been to drill the bone near the fractured ends, and, instead of inserting one suture, to use two long sutures passed through these drill holes so that the free ends are on opposite sides of the bone. The two sutures are tied simultaneously and the fixation obtained by the use of two sutures is far superior to that obtained from the use of one suture. The print, with no special attempt to obtain this, shows that the planes in which the radius and ulna were drilled were different, which also adds stability. I have uniformly sutured the radius first and have left the wound open and then repeated the performance on the ulna. Uniformly, the radius has held, and, in spite of tremendous force which often has to be applied in reducing the second bone, especially if the fracture is some days old, the radius was always found to have maintained its reduction after the suture of the second bone.

My own preference has been for the use of No. 4 chromic catgut, instead of kangaroo tendon, as the kangaroo tendon is not uniform in size, frays

\* Presented at the Orthopedic Section of the New York Academy of Medicine, April 24, 1931.

easily, and cannot be tied securely, all of which desirable characteristics are present in the chromic gut.

Figures 2 and 3 are X-ray films of a typical case in which this method of suture has been followed. All of these operations were done under the tourniquet and it is interesting to note that three of the seven cases presented the post-operative complication of loss of function of the nerves of the hand and fingers, which persisted over a period of about three weeks, when

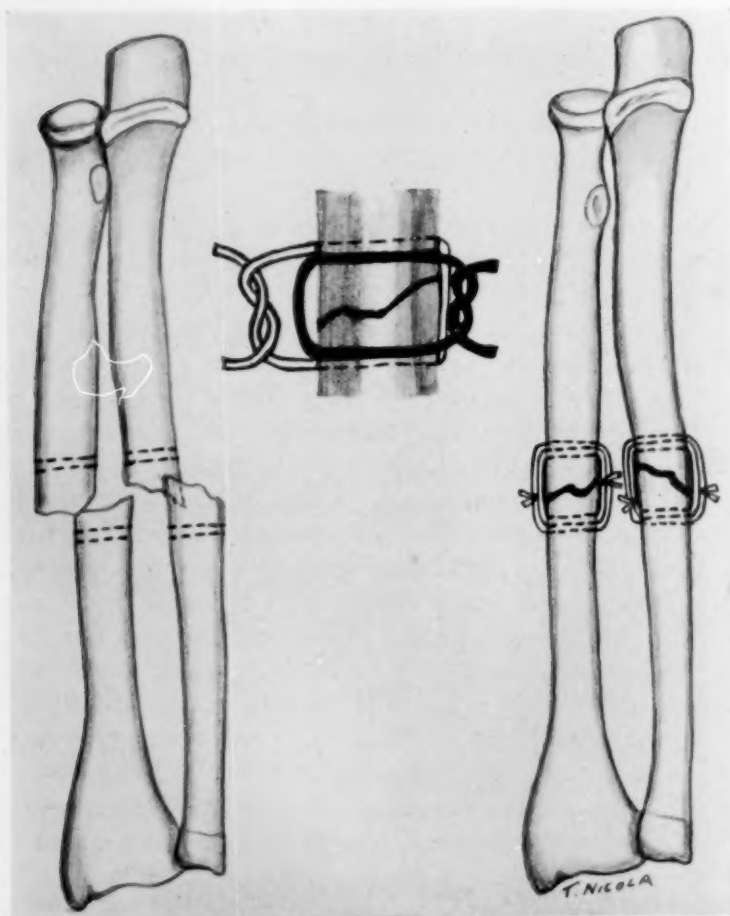


FIG. 1.—Method of insertion of the double suture.

the sensory and motor power had returned almost completely. They were all immobilized in circular plaster-of-Paris bandages. These bandages were left on for five weeks. The bandages extended from the metacarpo phalangeal joints to the axilla, with the wrist in slight dorsal flexion, the forearm supinated, and the elbow at a right angle. Care was taken that the bandages were not tight, so that this lack of nerve function was due to the tourniquet and not to the plaster-of-Paris bandage, as the fingers were but slightly swollen and their color was good. In spite of this in these particular cases the bandages

## SUTURING THE BONES OF THE FOREARM

were split through down to the skin without any change in function. Ultimately their nerve restoration was complete.

In one case in which the ulna was in fair position I did not suture this. The subsequent result was considerable displacement of the ulna, after the radius had been perfectly reduced. Interestingly enough, this patient developed an ulnar-nerve paralysis, both sensory and motor, with claw hand, and nearly three months after his fracture, I explored the ulnar nerve at a

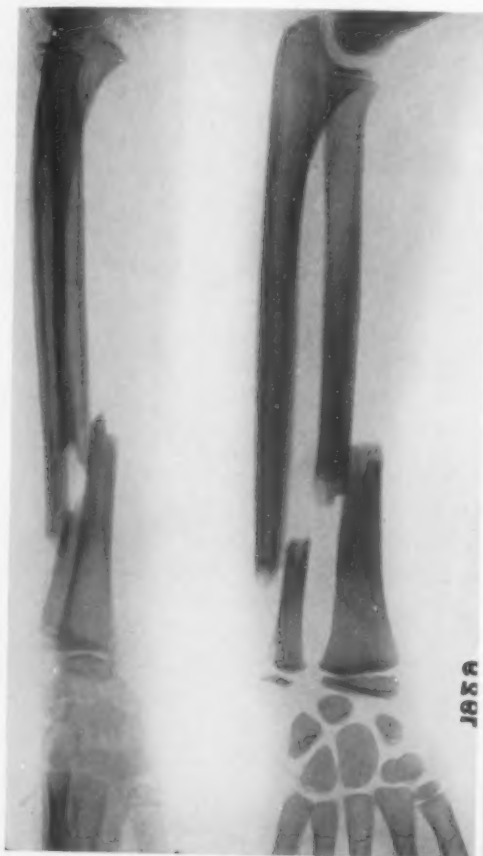


FIG. 2.—J. H. Fracture of the bones of the forearm. Before reduction.



FIG. 3.—J. H. Fracture of the bones of the forearm. One month later after the removal of the plaster-of-Paris bandage.

point several inches above the wrist joint at the site of fracture, and found the branches firmly imbedded in a mass of scar tissue. It was impossible to completely free these nerve branches as they began to fray out. I stopped after doing what was to me a very unsatisfactory operation. A day or so after the operation the patient was quite sure he had better control of the affected fingers though objectively I could distinguish no difference. Ten days after operation his sensation in the distribution of the ulnar nerve was complete though I could still find no change in the motor function. Two months later

the return of both motor and sensory function was complete. This return of function was an agreeable surprise to me as I felt that the operative procedure was inadequate. All of these patients have made complete recoveries, with two exceptions, the two most recently operated upon. They are joining up satisfactorily at the present time, though union has been delayed. There was an infection in one case and subsequently several sequestra were extruded, but the bony union and function were not impaired.

I have, on several occasions, as, for instance, in the patella or in a clavicle, used two sutures with the knots tied on the same side of the bone to obtain additional security. I feel that this is a desirable method of suture. This is obviously not the method that I am describing.

# TRANSACTIONS

OF THE

## PHILADELPHIA ACADEMY OF SURGERY

STATED MEETING HELD MAY 4, 1931

The President, DR. GEORGE P. MULLER, in the Chair

CALVIN M. SMYTH, JR., M.D., Recorder

### INTRAHEPATIC CALCULUS—CALCULOUS CHOLECYSTITIS COMMON-DUCT STONE

DR. HUBLEY R. OWEN reported the case of a woman who was admitted to the hospital of the Woman's Medical College, June 9, 1930, with the chief complaint of pain in the right side of the abdomen and back. The present illness began two months before with pain in the epigastrium which was at first referred to the left axilla then to the right lower costal margin, at times radiating to the left shoulder blade. The pain was inconstant and had no relation to the taking of food. There were associated headache and nausea. She had had the usual diseases of childhood, and pneumonia. She was operated upon at another hospital in 1921 for gall-stones, at which time cholecystostomy was performed. On admission there was no evidence of jaundice. Generalized tenderness over the abdomen especially over the region of the gall-bladder and epigastrium. This tenderness extended to the umbilicus. The liver was enlarged and extended almost to the level of the umbilicus. The spleen was not palpable. One hour after admission she had a severe attack of biliary colic; she was nauseated, vomited and the temperature arose to 103°. Her blood sugar on admission was 112.5, creatinin 1.4; chlorides 436, and blood urea 32 per 100 milligrams blood. On July 7, 1930, the blood sugar was 91; urea 17; and chlorides 400. The temperature gradually fell to normal and she was operated upon June 16, 1930, seven days after admission.

At the time of operation the liver was found to be greatly enlarged. The gall-bladder was large, thick-walled and contained innumerable calculi. The common duct was dilated and contained a large stone at its distal end. The gall-bladder and the common-duct stone were removed. A calculus was felt in the hepatic duct. An attempt was made to remove this calculus with a pair of Kelly forceps but the calculus crumpled and could be only partly removed. On palpation of the dome of the enlarged liver, an area of induration could be felt. With bi-manual palpation, one finger in the hepatic duct, the other hand being placed on the area of induration in the dome of the liver, it was found that the calculus was deeply embedded within the liver substance. The dome of the liver was incised with the cautery. A large branching calculus, 7 centimetres long and 3 centimetres in circumference, was removed through the incision in the dome of the liver. The calculus extended down the right hepatic duct. A "T" tube was placed in the common duct and a cigarette drain was placed to the incision in the liver which was not closed. Packing was unnecessary as there was no hæmorrhage. All sutures were removed ten days after the operation. There was very scanty drainage from the wound. After a rather stormy convalescence the patient was discharged on the twenty-ninth day after operation.



The reporter remarked that cases of hepatic-duct calculi are not uncommon. Intrahepatic calculi, especially of large size, are rather rare. Either may occur in the absence of calculous cholecystitis.

Frerichs<sup>1</sup> states that gall-stones in the interior of the liver and in branches of the hepatic duct are rare but quotes Morgagni who collected a series of observations from the works of Plater, Fallopius, Dodonoeus, Columbus, Paysch and others showing concretions which have been found in the interior of the liver. Most of these concretions were large, round stones and more rarely branched coral-like concretions which form casts in the ducts and are sometimes solid but at other times hollow. These concretions may give rise to inflammation, ulceration of the ducts also to hepatic abscesses and pylephlebitis.

There are said to be many specimens of multiple intrahepatic calculi in the museums of London and Westminster Hospitals. Beer<sup>2</sup> dissected 250 livers of patients who had succumbed to gall-bladder disease and found six cases of definite intrahepatic stone formation; that is, in 2.5 per cent.

Thudichum<sup>3</sup> reported six cases of large branching intrahepatic calculi. Another case of intrahepatic calculus was reported from St. George's Hospital of a man who died with diabetes from a secondary pancreatitis.<sup>4</sup> Vachell and Stevens<sup>5</sup> reported a case in which there were 520 calculi within the liver substances and the ducts. The largest was one and three-quarters inches long.

Intrahepatic calculi are chiefly composed of bilirubin calcium, whereas stones found in the gall-bladder are usually cholestrin stones. Because of this difference in the consistency of the calculi and because of the fact that intrahepatic stones may occur independently of calculi in the gall-bladder, the etiology requires further discussion. Beer<sup>6</sup> states that intrahepatic stones are probably formed in the liver rather than having been formed originally in the gall-bladder because of the fact that the stones removed from the hepatic duct and liver differ in shape, color and character from those usually found in the gall-bladder. Moreover, as mentioned above in many cases reported of intrahepatic stone, there have been no stones in the gall-bladder. Undoubtedly the intrahepatic calculi and the calculi found within the hepatic ducts must originate in the liver. In some cases of intrahepatic calculi, jaundice is present. In others, it is absent as in Draper's case.<sup>7</sup> In Hawkes' case<sup>8</sup> there was slight jaundice. In this case the gall-bladder had been previously removed. The patient left the hospital two weeks after cholecystectomy but attacks of pain continued. The patient was subsequently operated upon. No calculi were found in the ducts but "upon passing the hand upward toward the dome of the liver on the right side, a large calculus was found embedded in the liver substance about four inches from the free border of the liver." Hawkes performed this operation in two stages, introducing sterile gauze at the first operation to form adhesions. At second operation, four days later, the liver substance was incised and the calculi "dug out with the index finger from an indurated mass of surrounding tissue." Three large calculi were removed. There was considerable hæmorrhage which was checked by tamponade. In Doctor Owen's case the cautery was used for the liver incision and no worrisome hæmorrhage occurred. Hawkes suggests the advisability of palpating the liver surface during operation in cases diagnosed as cholelithiasis where the findings in the region of the gall-bladder and ducts do not seem sufficient to account for the symptoms present. He further states that it "seems possible that liver abscesses of unknown etiology have arisen from such cause." Vachell and Stevens<sup>9</sup> reported a fatal case of intrahepatic calculus associated with multiple abscesses of the liver and subdiaphragmatic abscess. The gall-bladder in this case was normal in size and contained no calculi. Jaundice was not present until nineteen days before death. Chemical analysis of these calculi showed a predominance of calcium bilirubin. The culture from the abscesses of the liver showed *Bacillus coli* and whereas the patient had typhoid a number of years before, the typhoid bacillus was not found.

## MULTIPLE NEURITIS AFTER INJECTION OF TETANUS ANTITOXIN

Again in Draper's case *ibid* occurring on the service of Dr. Arthur Newlin, at the Pennsylvania Hospital, there was no jaundice present and no local pain or tenderness. This case was not operated upon. At autopsy there were found one stone half the size of an egg, and a large intrahepatic stone with abscess of the liver. Lewisohn<sup>10</sup> reported a case of intrahepatic stone formation, there being several stones in the liver passages, one rupturing through the surface of the liver and causing general peritonitis. Jacobson<sup>11</sup> suggests that, in many secondary operations performed on cases of gall-bladder disease when stone is found in the common duct at the second operation, the apparent recurrence of the stone, which the surgeon at the time thinks was overlooked at the first operation, is actually an intrahepatic calculus which may have been present at the first operation but has descended to the common duct subsequent to the preliminary operative procedure. Weber<sup>12</sup> reported a fatal case of intrahepatic calculi. The case was operated upon for calculous cholecystitis and the gall-bladder was removed. The patient died three days after operation and at post-mortem there were found unrecognized intrahepatic calculi. He further emphasizes the fact that in intrahepatic calculi, though the hepatic duct actually appears to be blocked, jaundice may be variable in degree or even absent. McArthur<sup>13</sup> reported a fatal case of intrahepatic stone associated with stone in the common duct. There were no stones in the gall-bladder. McArthur discusses at length the etiology of calculous cholecystitis and intrahepatic calculi and reaches the following conclusions:

1. All gall-stones do not originate in the gall-bladder.
2. The origin of cholesterol stones is probably in the gall-bladder with subsequent growths either in the gall-bladder or ducts where they may lodge.
3. Bilirubin calcium is the constituent of the smaller intrahepatic duct stones.
4. Calculi in immense numbers may have existed for months in the ducts without producing a symptom.
5. The surgeon need not reproach himself too much if there be recurrence of the symptoms after common duct drainage.

This case is reported to emphasize three points:

1. The method of approach through the dome of the liver to remove the intrahepatic calculus.
2. The use of the cautery for the liver incision which minimized hæmorrhage.
3. The instance of post-operative hyperglycæmia due either to temporary chemical change in the pancreas or trauma to the pancreas inflicted at the time of operation. This temporary hyperglycæmia has been noted in a number of our gall-bladder operations.

### REFERENCES

- <sup>1</sup> Clinical Treatise on Diseases of the Liver, vol. ii, p. 512.
- <sup>2</sup> Archives of Clinical Surgery, vol. lxxiv, p. 115, 1904.
- <sup>3</sup> A Treatise on Gall-stones, p. 176, 1863.
- <sup>4</sup> Transactions of the Pathological Society, vol. xlix, p. 133, London, 1898.
- <sup>5</sup> British Medical Journal, vol. i, p. 134, 1906.
- <sup>6</sup> Medical News, vol. lxxxv, 1904.
- <sup>7</sup> Proceedings of the Pathologic Society of Phila., vol. xiii, p. 16, 1910.
- <sup>8</sup> Medical and Surgical Report, Presbyterian Hospital of New York, vol. vii, p. 230, March, 1906.
- <sup>9</sup> British Medical Journal, vol. i, 1906.
- <sup>10</sup> ANNALS OF SURGERY, vol. lxiii, p. 535, 1916.
- <sup>11</sup> Archives of Surgery, vol. i, 1920.
- <sup>12</sup> Clinical Journal, vol. i, p. 165, 1921.
- <sup>13</sup> Journal of A. M. A., vol. xlv, p. 1797, 1905.

## MULTIPLE NEURITIS FOLLOWING PROPHYLACTIC INJECTION OF TETANUS ANTITOXIN

DR. HUBLEY R. OWEN presented a man twenty-eight years of age, who, on December 18, 1930, received a punctured wound of the right foot. On

the following day 1,500 units of tetanus antitoxin were administered into the subcutaneous tissues of the anterior abdominal wall. On December 25 he developed a severe generalized urticarial reaction for which he received an injection of adrenalin. On December 28 he was awakened during the night with very severe pains in the neck, more severe on the right side, pains in both shoulders, hands, forearms and in the intrascapular areas. He could not move his fingers or wrists and both upper extremities were weak. His hands and forearms felt as though they were swollen. The pain, which continued until the end of the first week in January, was associated with numbness and tingling in the hands and forearms.

January 5 the following findings were noted: The power in the left upper extremity was normal, excepting for slight weakness of the hand grasp. There was marked weakness in the grip of the right hand, and about 70 per cent. loss of power in the extensors of the wrist. He complained of very severe pain in the neck, shoulders, intrascapular areas and both arms. There was tenderness over the muscles of the right side of the neck, the axilla and over all the nerve trunks in arms and forearms. Extreme abduction of the arm caused severe pain. No objective impairment of sensation could be elicited, but subjectively there were numbness and tingling of the right hand and forearm. Tenderness, not as severe in character, was noted over the nerve trunks of the left arm. Power of both deltoids normal. There was definite weakness of the biceps and triceps muscles of the right arm. The left biceps and triceps muscles were normal. The bicipital and tricipital reflexes could not be obtained on the right side, but were normal on the left.

The above symptoms improved slowly. On January 9 he was able to resume light duty. By January 19 he had recovered sufficiently to return to active duty. Recent examination reveals that the power in both arms and hands is normal and equal. On lifting weights there is a moderate winging of both scapulæ. The patient states that he does not appear to have the same strength in his arms and hands as he had prior to the attack of neuritis.

The speaker remarked that cases of multiple neuritis following the prophylactic injection of tetanus antitoxin have been previously reported. The first report in the literature is by Thaon.<sup>1</sup> Approximately twenty cases have been reported. This manifestation of allergy is a comparatively rare one. Braunlich<sup>2</sup> cautions against the use of fresh tetanus antitoxin, stating that as a result of its use, serum reaction occurs more frequently and is more severe. Multiple neuritis may follow prophylactic injection of tetanus antitoxin or other sera. The prophylactic or therapeutic use of serum must be administered with the realization of this fact. None of the present indications for the administration of sera should be ignored because of the comparatively rare complication of neuritis. More careful testing for sensitization is advisable in the use of anti-sera to avoid this and all other unpleasant complications of serum therapy.

## REFERENCES

- <sup>1</sup> Thaon: Review de Med., September, 1912.
- <sup>2</sup> Braunlich, George: Anaphylaxis Following the Injection of 1,500 Units of Tetanus Antitoxin. Iowa State Medical Journal, No. 17, p. 450, December, 1927.

## INFLAMMATORY REACTION OF THE LOOPS

In answer to the question whether the patient had ever received any injections of serum before, the reply was made that he had had an injection of anti-tetanic serum for a punctured wound about eight years ago. The speaker added that apparently those cases that are sensitized to serum are those in which this condition is more prone to develop. Prophylactic injection of toxin-antitoxin for diphtheria immunization has apparently been enough to sensitize many individuals to reactions of this sort.

DR. HUBLEY R. OWEN stated that in the police and fire departments of Philadelphia, it was necessary to give approximately three hundred prophylactic doses of tetanus antitoxin each year. In twenty-four years, this is the first case of neuritis which he had seen following the administration of antitoxin.

## INFLAMMATORY REACTION OF THE LOOPS FOLLOWING GASTROENTEROSTOMY

DR. FREDERICK A. BOTHE presented two cases developing high intestinal obstruction following gastroenterostomy for duodenal ulcer. Secondary operations were performed and in each patient an inflammatory process was found in both the proximal and distal loops of the gastroenterostomy, with associated obstruction of the stoma.

The first case, a male, fifty-six years of age, was admitted to the Presbyterian Hospital, August 20, 1930, with a typical history of duodenal ulcer of fifteen years' duration. Twenty-four hours before admission he had a large gastric hæmorrhage, and passed several tarry stools. On admission, the hæmoglobin was 62 per cent. red blood cells 3,600,000, and white blood cells 7,600. The routine management for the bleeding ulcer was instituted. On the fifth day the patient's general condition had improved; there was no evidence of bleeding and an exploratory laparotomy was performed with the pre-operative diagnosis of bleeding duodenal ulcer. At the operation a large duodenal ulcer was found in the first portion of the duodenum on the anterior wall. This was excised by the cautery, sutured, and the suture line was covered with a portion of the lesser omentum. A posterior gastroenterostomy and appendectomy were performed and at the conclusion of the operation, a blood transfusion of 300 cubic centimetres was given. The immediate post-operative reaction was satisfactory. Water was taken without any evidence of retention until the fourth day when fullness in the epigastrium and hiccoughs developed and the temperature rose to 101°F. Forty ounces of bile-stained fluid were recovered by gastric lavage. Blood chemistry studies showed a slight fall in the blood chlorides and an elevation of the blood urea nitrogen. The stomach was repeatedly lavaged with a Jutte tube and 1,000 cubic centimetres of 5 per cent. glucose in normal salt solution was administered intravenously twice daily. Although there was slight general improvement in the next thirty-six hours, the retention persisted and an exploratory operation was performed. Both the proximal and distal loops of the gastroenterostomy were markedly inflamed and the stoma was entirely closed. The inflammatory reaction extended down the proximal loop to within 2 inches of the ligament of Treitz and in the distal loop for the distance of about 5 inches. The ligament of Treitz was severed to mobilize the upper portion of the jejunum and an enteroenterostomy was made between the proximal and distal loops below the involved portions. A jejunostomy of the Witzel type was then performed. At the termination of the operation a blood transfusion of 300 cubic centimetres was given. Repeated gastric lavage and intravenous injections of glucose and salt solu-



tion were continued and in addition, 5 per cent. glucose in normal salt solution was administered through the jejunostomy tube by the Murphy drip. The patient's condition did not change very much in twenty-four hours, so a Jutte tube was left in the stomach and every two hours the gastric contents were aspirated and introduced into the jejunum through the jejunostomy tube. This procedure benefited the patient symptomatically and produced a definite improvement in the degree of dehydration in twenty-four hours. Charcoal was placed in the stomach after the aspiration at various intervals, but no trace of it could be found in the jejunum until seventy-two hours after the operation. On the fourth day the temperature became normal, and on the fifth day fluids passed through the stomach readily. Oral feedings were started and gradually increased; intravenous injections of glucose and salt solution were discontinued on the sixth day; feeding through the jejunostomy tube was discontinued on the eighth day, and the jejunostomy tube was removed on the fourteenth day. Subsequently, the convalescence was uneventful. Since his discharge from the Hospital, the patient has gained twenty-two pounds in weight and is symptom-free.

The second case, a man, forty-one years of age, was admitted to the Presbyterian Hospital April 18, 1927, under the care of Doctor Pfeiffer. He had an eight-year history typical of duodenal ulcer and the X-ray was positive for this lesion. April 22, 1927, a laparotomy was performed, a duodenal ulcer was found, and a gastroenterostomy and appendectomy were performed. The patient's immediate post-operative reaction was satisfactory and he was able to take soft diet with no discomfort. On the eighth day symptoms of gastric retention developed with an elevation of the temperature of  $100 \frac{1}{5}^{\circ}$  F. Gastric lavage was performed and glucose and saline were administered intravenously. Blood chemistry studies showed a more severe alkalosis than was found in the first patient. The  $\text{CO}_2$  was 85 volumes per cent., the blood chlorides were 208 and the blood urea nitrogen, 26 per cubic metres of blood. The patient's condition became progressively worse and the gastroenterostomy was explored on the twelfth day. Both the proximal and distal loops were greatly inflamed, the stoma was closed and the distal loop was collapsed beyond the area of inflammation. An enteroenterostomy was made between the two loops. Gastric lavage and intravenous medications were continued. There was slight improvement for twenty-four hours, but the patient's progress was not satisfactory. On the second day a jejunostomy was performed with a marked relief of symptoms in twenty-four hours. Forty-eight hours after the jejunostomy the patient's temperature fell to normal and at the end of four days fluids passed through the stomach into the jejunum. The diet was gradually increased until solid food was taken with no evidence of retention. Three weeks after the jejunostomy, when the patient had completely recovered from the gastric retention, an upper respiratory infection occurred which was complicated by multiple abscesses of the lung and empyema which was ultimately responsible for his death, two and one-half months after the original operation. The respiratory condition is mentioned briefly as before the onset of this complication, the inflammatory reaction of the loops of the gastroenterostomy had subsided and the patient was well on the road to recovery.

These cases are presented for two reasons: First, inflammation of the loops was the cause of gastric retention following gastroenterostomy; and secondly, the jejunostomy placed the inflamed area at rest, permitting the inflammation to subside and thereby relieving the obstruction.



## INFLAMMATORY REACTION OF THE LOOPS

The etiology of the inflammatory process could not be determined. Both gastroenterostomies were performed in the routine manner and no inflammation was present at the time of the primary operation. There were several findings in the post-operative course which were considered of significance in arriving at this diagnosis. First, the onset of the symptoms of gastric retention developed suddenly in patients who were apparently taking oral feedings very satisfactorily, and secondly, there was a simultaneous elevation of the temperature. The sudden onset of symptoms may be explained by the fact that the inflammatory reaction had gradually encroached upon the lumen of the stoma, and it was not until the stoma was completely closed that the gastric retention occurred. The elevation of temperature is a valuable sign when there are no other physical findings to account for it.

Doubtless cases occur in which the inflammatory reaction is not severe enough to produce a complete obstruction. Possibly some cases which do not take fluids as well as usual, following gastroenterostomy, would fall into the milder group. A case which the speaker believed to be of this nature, occurred in the service of Doctor Speese, at the Presbyterian Hospital, in 1927. This patient did not have complete retention, but the gastroenterostomy did not relieve his symptoms. X-ray studies made two years after operation were suggestive of marginal ulcer. An exploratory operation revealed no evidence of marginal ulcer, as suggested by the X-ray, but the loops of the gastroenterostomy were bound down to the transverse mesocolon by dense adhesions. The stoma was found to be patulous and would admit two fingers. The adhesions were freed and the raw surface thereby produced, covered with omental grafts. Since the second operation the patient has had no further symptoms. This case strongly suggests a mild type of inflammatory reaction and with the subsidence of the inflammation, the loops became adherent to the transverse mesocolon in such a way as to produce mechanical interference to the proper functioning of the gastroenterostomy.

Jejunostomy has been shown to be of great value in inflammatory lesions of the stomach and upper gastro-intestinal tract, and in these two cases apparently it was the most important procedure in the relief of the obstruction.

Balfour has called attention to the value of jejunostomy in the treatment of apparently irremovable lesions of the stomach, complicated by inflammation. He has observed a number of cases with complete disappearance of symptoms after a few weeks of feeding through the jejunostomy tube and without recurrence following removal of the tube. The length of time for the tube feedings will depend on the röntgenologic evidence as to what changes are taking place in the lesion. If supplementary oral feedings become advisable, they should be based on a strict antiulcer régime. It is possible in some cases to perform secondary operations on the patients after some weeks, and excise the lesion when the inflammation has subsided. He reports a case operated upon in October, 1927, for a marginal ulcer following partial gastric resection. The ulcer had perforated onto the diaphragm and there was an extensive inflammatory process around it. A huge crater could be identified on the anterior part of the anastomosis. Owing to the great risk and technical

difficulties of major operative interference, a jejunostomy was performed. The patient had relief from pain in eight days; the jejunostomy tube was left in place for six months and during that time no food was taken by mouth. Eight months after the operation the patient returned symptom-free, all evidence of the lesion had disappeared and the X-ray was negative.

DR. DAMON B. PFEIFFER said that since the standardization of the technic of gastroenterostomy has been so well placed before the profession by many surgeons, notably Moynihan, we have become accustomed to think little of what was formerly called vicious circle. The physiologic gastroenterostomy makes it very much simpler for the contents of the stomach to enter the jejunum rather than go down to the proximal loop. These two cases show that there is a type of obstruction which is not a simple mechanical one but which is due to adynamic ileus. The speaker has seen a somewhat similar condition in the colon in which the bowel had lost its elasticity. One sees it most frequently in the late stages of ulcerative colitis. The physiologic block is not due to any actual obstruction but to the inflammatory ileus. He would hesitate very much to delay operation in cases showing marked gastric retention after gastroenterostomy, hoping it would disappear. It might disappear but the proper thing to do is to explore.

DR. EDWARD T. CROSSAN said that Doctor Bothe states that the gastroenterostomy was done in the usual manner. He would like to know whether the "usual manner" means that there were three layers of sutures posteriorly, or whether two layers were used. He would also like to know whether the opening in the transverse mesocolon was sutured close to the stoma. It would appear that if three layers of suture are used posteriorly, and in addition to this the rent in the mesocolon be sutured close to the stoma, there is sufficient irritation from the foreign bodies to cause an inflammatory reaction such as described in these cases. The speaker agrees with Doctor Pfeiffer that jejunostomy should clear up cases of inflammatory ileus.

DR. GEORGE P. MULLER remarked that operative interference was often unwisely postponed in the hope that obstructive symptoms would be relieved. This practice occasionally results in the neglect of a patient suffering from severe mechanical obstruction. The speaker, however, recalled one patient whom he had ordered prepared for re-operation when it was discovered that there was a marked alkalosis. Large quantities of hypertonic saline and glucose solution were given and in twenty-four hours the clinical picture had completely changed. Doctor Muller, therefore, advocates serious consideration of the chemical state of affairs and if treatment along these lines fails to give relief, operation should not be delayed. In certain cases infection from the stomach may be carried to the suture line and thus produce an inflammatory reaction in the stoma which will prevent it from functioning.

DR. FREDERICK A. BOTHE said that he used two rows of sutures and sutured the mesocolon about two and one-half inches from the anastomosis.

## AVERTIN ANÆSTHESIA FROM THE SURGEON'S STANDPOINT

### PENETRATING WOUNDS OF THE ABDOMEN

DR. ARTHUR E. BILLINGS and DR. ADOLPH WALKLING read a paper with the above title.

DR. CHARLES F. NASSAU remarked that there is one thing that he has missed in Doctor Billings' paper and that is the relationship between the result and the calibre of the bullet. Over a good many years he had the opportunity to operate upon gunshot wounds of the abdomen; not many stab wounds. With but two exceptions he has never seen anybody shot by a 38-calibre bullet get well. Those shot with 22-and 32-calibre bullets make almost uninterrupted recoveries where there is not too much irreparable damage done. He had under his observation one 38-calibre wound get well and one wound from a 41 Swiss pistol where the bullet was never found. He thinks it would be interesting if there were some way in which Doctor Billings could look up the calibre of the bullets that caused the injuries and show whether there is any basis in his cases for Doctor Nassau's belief.

DR. ARTHUR E. BILLINGS replied that he had thought of investigating that question but the calibre of the bullet is so seldom known in most cases that he was unable to get enough histories to make it of any value.

## AVERTIN ANÆSTHESIA FROM THE ANÆSTHETIST'S STANDPOINT

DR. JOSEPH KREISELMAN (by invitation) read a paper with the above title for which see page 885.

## AVERTIN ANÆSTHESIA FROM THE SURGEON'S STANDPOINT

DR. CHARLES S. WHITE (by invitation) read a paper with the above title for which see page 888.

DR. CHARLES H. FRAZIER said that the performance of cranial operations is different from those of the abdominal or general surgeons in that relaxation is not a very important factor. In cranial exploration under local anæsthesia alone he found that the method was entirely satisfactory in most respects, that is, in so far as being able to operate without pain. Cranial explorations are long drawn out affairs and patients are often on the table for two hours. There is a tendency for the pulse rate to become high and the blood pressure to fall. The addition of small amounts of ether improved the blood pressure and the irregularity of pulse would disappear. Doctor Grant and the speaker have tried avertin in a number of cases and in every respect it seems satisfactory. His anæsthetist experimented as to the dosage, it being desirable, of course, to use a minimum dose. She started with 80 milligrams and found it a little too much, there being a tendency to cyanosis and the early fall in blood pressure. At present she has found that 60 milligrams is quite sufficient. The administration is simple. The patient is given a colonic irrigation about one hour before being brought to the anæsthetizing room and fifteen minutes before that one-half grain of codein, followed in a few minutes by the avertin. Occasionally there is a fall in blood pressure within fifteen to twenty minutes, but it usually responds of itself. Occasionally he gives one-half an ampoule

of pituitrin. Doctor Frazier's experience with this dosage has been satisfactory and gave no cause for alarm.

DR. GEORGE P. MULLER said he saw the publication of Doctor White's previous paper. He had begun the use of avertin and during the winter had used it in forty-three cases, of which about half were goitre. Forty were successful from the standpoint of anaesthesia. Blood pressures usually fell for a short period but not nearly so much as occurred in spinal anaesthesia. Nitrous oxide gas was used as a secondary anaesthesia and the patients required but little of it. No patient showed any complication from the avertin.

DR. EDWARD W. BEACH said that he had used avertin, not so much as the essayists, but had found it very satisfactory. There is a drop in pulse pressure early in the anaesthesia. The reaction is very quick. Cyanosis has not given trouble although he always has a tank of CO<sub>2</sub> and oxygen present. He varies the dosage according to the operation; in major abdominal work using the larger doses. The advantage of nitrous oxide as the supplemental anaesthetic is that one maintains a high percentage of oxygen which is desirable as it maintains a higher metabolic rate. In other words, one can conduct a section on a 50-50 instead of an 80-20 mixture. Doctor Beach thinks avertin possibly impairs the action of the kidneys at first but only temporary. It certainly is an approach toward the ideal, and the patients are all well pleased.

DR. CHARLES S. WHITE, said that he believed the proper way to use avertin is to begin with a small dose, 60 milligrams for instance, and gradually increase it in various cases until the proper dosage is reached. This will be 80-90 milligrams per kilo. of body weight. He did considerable laboratory work in connection with avertin, but did not go into the matter of dosage because this has already been well worked out by the Germans. He believes avertin is a distinct advance in anaesthesia and is well worth trying. For a long time he has been considering the anaesthetic from a surgeon's standpoint, in his opinion it is now time to give the patient due consideration.

DR. JOSEPH KREISELMAN, replying to questions, said that he was not prepared to make a comparison between amytal and avertin. He had never used the former. It is a little difficult to give a definite dosage. In the beginning he used 100 milligrams almost routinely for abdominal surgery. He would use 100 milligrams in a young healthy adult man now; perhaps in a young woman. In an obese patient, say 160 pounds, he probably would use somewhere between 80 and 90. A recent patient who weighed about 170-180 pounds and had a blood sugar of 300 received what he estimated to be about 50-60 milligrams and there was practically no change in her blood sugar post-operatively. He has never used it intravenously. The speaker does not consider 80 milligrams enough for the average abdominal operation. On occasions 100 milligrams is slightly exceeded. The respiratory rate is decreased with the larger doses. Cyanosis has not been observed in any case.

## BRIEF COMMUNICATIONS

### PREPARING POUCHES OF THE FUNDUS OF THE STOMACH

IN PREPARING pouches of the fundus of the stomach large enough to obtain a satisfactory quantity of gastric juice, difficulty is experienced with excoriation of the skin and abdominal wall surrounding the fistula, even if antacids are used and continuous drainage of secretions is instituted. Mann and Bollman<sup>1</sup> have described a method of preparing intestinal fistulas which we have modified in preparing such pouches.

Under ether anaesthesia, and strictly aseptic technic, the abdomen is opened through a median-line incision from just below the xyphoid process to the umbilicus. A segment of the terminal ileum from 10 to 15 centimetres long

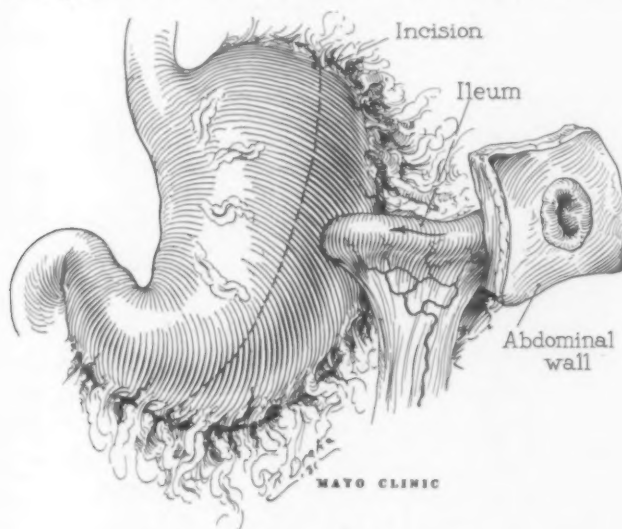


FIG. 1.—First stage of fundus pouch.

is resected, its blood supply being preserved. Intestinal continuity is reestablished by end-to-end suture. The distal end of the resected loop is sutured to an opening made high along the greater curvature of the stomach, whose diameter is somewhat smaller than that of the intestinal loop. The proximal end is brought cut through a stab wound made in the abdominal wall under the left costal margin in the nipple line and fixed to the fascia and skin with several interrupted sutures (Fig. 1). The abdomen is closed in layers. After healing is completed, usually in from twelve to fourteen days, the abdomen is reopened through the same incision, and a portion of the stomach drained by the fistula in the intestinal loop is made into an isolated pouch of either the Pavlov or Heidenhain type (Fig. 2).

The peristaltic wave in the loop of bowel is away from the abdominal wall, which tends to return secretions to the pouch, giving it a valve-like action. If



## BRIEF COMMUNICATIONS

there is an overflow of secretion so that it reaches the skin, it has passed over 10 to 15 centimetres of intestinal mucosa, and excoriation is reduced to a minimum. In several months of observation we have not seen leakage from the fistulas, thus raising the question of absorption of the acid by either the stomach or more probably the ileum mucosa. We hope to answer this question in the near future. The two-stage procedure enables the fistulous opening to become well healed before any appreciable amounts of acid secretions pass over it.

The animals used in such experiments do not require special care. At any time about 20 cubic centimetres of gastric juice can be obtained, the amount depending on the size of the pouch. The small amount of secretion of the loop of intestine returning to the pouch can be readily prevented, when pure

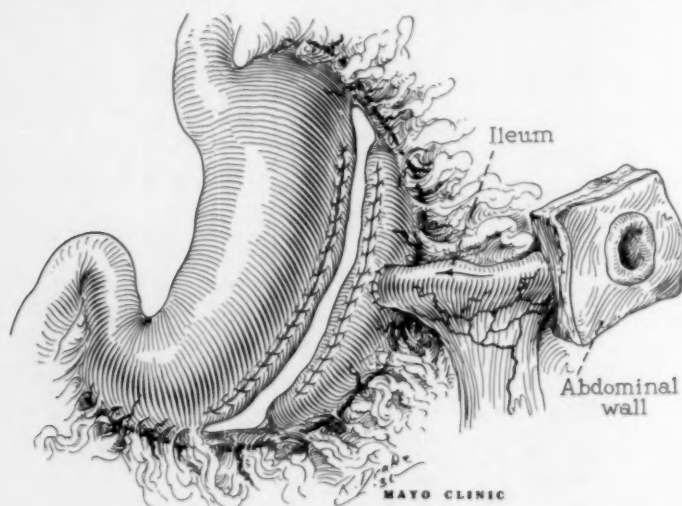


FIG. 2.—Second stage of fundus pouch.

gastric juice is desired, by inserting a Pezzer mushroom catheter well within the pouch and exerting enough traction on it to impinge the mushroom against the contracted line of the gastro-ileal anastomosis. Acid values are in every way comparable to those obtained in dogs with a Pavlov pouch; excoriation and continuous care are eliminated and sufficient volume of secretion can be obtained for practically all experimental purposes.

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## BIBLIOGRAPHY

- <sup>1</sup> Mann, F. C., and Bollman, J. L.: A Method for Making a Satisfactory Fistula at Any Level of the Gastro-intestinal Tract. *ANNALS OF SURGERY*, vol. xciii, pp. 794-797, March, 1931.

# CALIBRATED SURGICAL DRAINS

WITH the use of conventional drainage material such as rubber tubing, rubber dam and cigarette drains, the post-operative care of patients with surgically drained lesions is sometimes complicated, by virtue of the fact that the surgeon does not at all times know the exact depth to which the drain is introduced into the operative wound.

Very often in hospital ward practice because of the fact that several physicians may dress the same patient and shorten drains from day to day, it is impossible to know the exact length of the drain at a given time, without the troublesome and time-consuming procedure of frequently consulting the clinical chart. Even then, the length of the drain may still be in doubt, unless the amount which it has been shortened at each dressing has been accurately recorded.

The reverse of this situation obtains, when the surgeon desires to introduce a drain, at the time of operation, into a cavity for a specified distance. Being unable to readily ascertain the length of that portion of the drain which he has just introduced into the wound, he must next withdraw it to approximate its length, and then re-introduce it for the desired distance. The importance of knowing the exact depth to which the drain is introduced—for instance, into a brain abscess cavity or into a pulmonary or pleural cavity, where impingement of the end of the drain on various important structures is to be avoided—is obvious. Similarly, knowing the depth to which a tube is introduced through the abdominal wall into the peritoneal cavity or into a hollow viscus such as the gall-bladder, the common bile-duct, stomach, intestine, ureter, or bladder, makes for precision and allows one to note immediately whether the tube has been displaced or has become accidentally partially withdrawn, at any time after introduction.

Many surgeons use cigarette drains for primary drainage and replace these drains in the course of a few days with rubber tubes. By knowing the exact length of each drain beforehand, the process of replacement of the cigarette drain by the rubber tube is simplified and is devoid of the trauma which, of necessity, occurs when one attempts to force a drain to the very bottom of an existing sinus tract of uncertain depth.

In an attempt to make for greater accuracy and precision, and to obviate some of the difficulties described above, we endeavored by several methods to calibrate numerous lengths of rubber drainage tubing. Various indelible inks and paints proved fairly satisfactory until the tubes were boiled. After numerous trials, the results of which were unsatisfactory, we conceived the idea of having the calibrations printed on a rubber strip, which in turn could be affixed to the drainage material. In coöperation with Mr. John R. Foley, of the Orrsell Company of New York City, we finally improved on this plan, and devised a new type of calibrated drainage material which has proven highly satisfactory during the past four months of use.

The calibrations, which are one-half centimetre apart, are vulcanized

# BRIEF COMMUNICATIONS

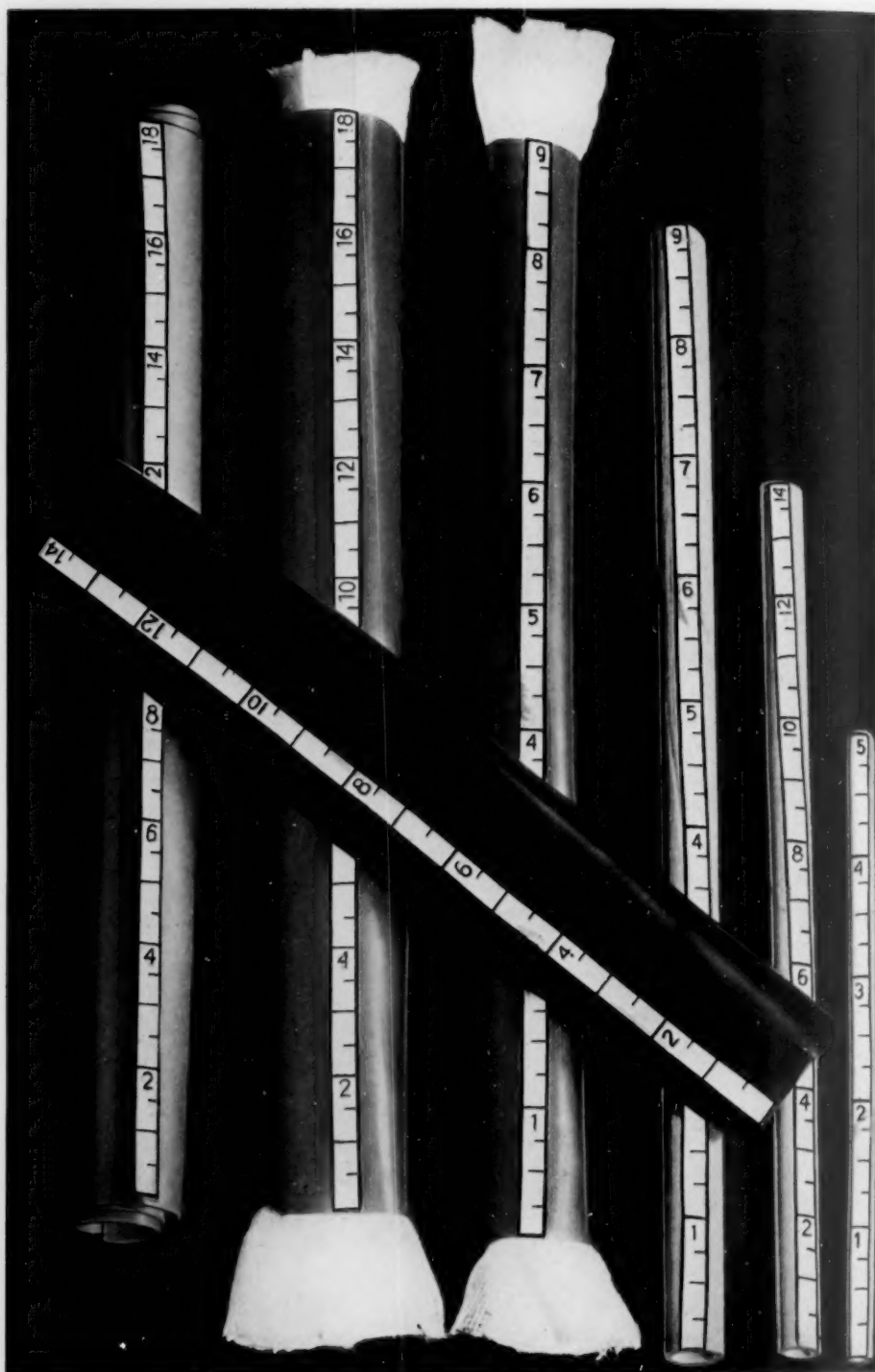


FIG. 1.—(1) Rubber tubes (various calibres) calibrated in centimetres and inches. (2) Cigarette drains calibrated in centimetres and inches. (3) Rubber dam calibrated in centimetres. (4) Penrose tube calibrated in centimetres.

## MODIFIED STEWART SUTURE

directly on a very thin strip of rubber four millimetres wide which constitutes the background. (Fig. 1.) This calibrated rubber strip in turn is vulcanized and processed directly to the rubber tube, dam, or Penrose tube as the case may be. The entire unit is then coated with a very thin layer of rubber which imparts to it a smooth finish. Thus the calibrations which are now an integral part of the drain are of permanent character, and do not fade even when exposed to corrosive discharges or subjected to repeated boiling or chemical sterilization. We have had the calibrations placed on strips of white, red, yellow and green rubber, thus providing contrastingly colored backgrounds.

The value of using drains marked with distinctive colors is obvious when the necessity arises for introducing through a single wound several drains into different parts of the same cavity. By noting the colors of the calibrated strips on the drains introduced into the different areas at the time of operation, it becomes unnecessary to designate them with external markers, and thus another troublesome and time-consuming feature is obviated.

It is common practice in many hospital operating rooms to supply to the surgeon drainage material cut into twelve-inch lengths. The operator selects the type of drain he desires, cuts off the required length, and discards the remainder. A considerable waste of material thus occurs. In the interests of economy, we have had our drains supplied to us in ten-, fifteen-, and twenty-centimetre lengths and have found that the saving effected thereby has enabled us to use the calibrated material at only very slight increase in cost over that of the ordinary type.

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*From the Surgical Service of Dr. Harold Neuhof, Mount Sinai Hospital*

## A MODIFICATION OF THE STEWART SUTURE

HOWES, SOOY and HARVEY showed that if the edges of wounds in the entire thickness of skin were immediately approximated with sutures so as to bring the entire depth in accurate apposition, the epithelium bridges the surface so rapidly that epidermization does not appear as a factor. They also showed that there is an initial quiescent or "lag" period (Robertson) in the healing process represented by the time up to the fifth day. The strength during this period is that of the holding power of the suture. The tensile strength of a healing wound is a function of the fibroplastic process which takes place in the phase of fibroplasia. The maximal strength of the wound being attained by the latter process in from ten to fourteen days, the suture to be described tends to give skin wounds the optimum physiologic requirements as described above for perfect healing, besides the purely cosmetic results obtained.

Fig. 1 shows the very useful and usual suture (Stewart's) used in closing up skin wounds.

## BRIEF COMMUNICATIONS

Fig. 2 shows its modification, and might be termed a subcuticular type of Stewart suture. The suture is introduced by a straight cutting needle at point (A) on side of assistant to point (B), similar to the usual Stewart stitch, going to deeper layers of skin and subcutaneous tissues to obliterate any dead space.

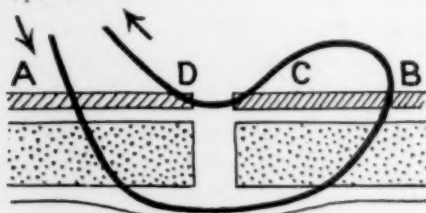


FIG. 1.

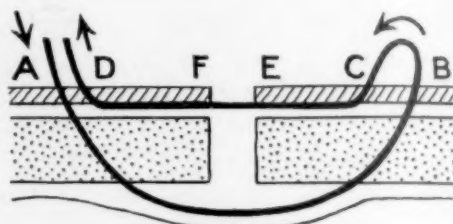


FIG. 2.

Instead of going to point (C) Fig. 1, the needle is then directed to point (C) Fig. 2, one-quarter of an inch medial to point (B) and allowed to pass directly under the skin and emerge at point (E)—edge of incision.

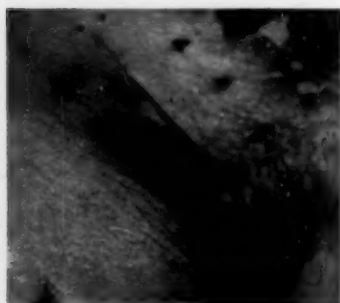


FIG. 3.—Herniotomy wound. Ninth day, post-operative, upon removal of above type of suture. Note only three sutures used; hair-line scar; absence of cross marks.

Then the needle is passed subcuticularly from point (F) to (D), the latter emerging one-quarter of an inch medial to point (A).

The suture is then tied, giving a perfect hair-line wound approximation similar to a subcuticular suture.

This suture can readily be removed by cutting either end and pulling out.

The suture as used on clean cases at the Bellevue Hospital has proved very satisfactory. The suture is easily applied, gives an excellent hair-line approximation, avoids cross wound cutting and scarring, and is easily removed.

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## BIBLIOGRAPHY

- <sup>1</sup> Howes, E. L., Sooy, J. W., and Harvey, S. E.: The Healing of Wounds as Determined by their Tensile Strength, *J. A. M. A.*, vol. xcii, pp. 42-45, January 5, 1929.
- <sup>2</sup> Robertson, T. B.: *Principles of Biochemistry, etc.*, Philadelphia, 1924.



## BOOK REVIEWS

LA CHIRURGIA DELLA INNERVAZIONE PERIFERICA DEL SIMPATICO (CHIRURGIA DEL DOLORE). BY PROF. IGNAZIO SCALONE. 8 vo.; pp. xvi-256. Ulrico Hoepli, Milano, 1931.

Surgery of the Peripheric Innervation of the Sympathetic System is the title of a monograph written by Scalone, of Milano, which carries as subtitle, in red type about twice the size of the title, "Chirurgia del Dolore" (Surgery of Pain).

It would not be fair to offer a criticism of such an excellent monograph without remarking that both the title and the subtitle, especially the latter, to which the large red type used calls the attention of the reader, are misleading. The monograph does not truly deal with "The Surgery of Pain" or with the surgery of the innervation of the sympathetic system; it deals only with certain special phases of these subjects, to which Scalone has devoted a great deal of personal consideration. Thus, for instance, no mention is made of trigeminal neuralgia, which causes the most intense and often most irremediable of pain.

These limitations stated, nothing but praise should go to Scalone for his conscientious, intelligent and honest endeavor. The monograph was selected by the Reale Istituto Veneto di Scienze, Lettere ed Arti, as deserving the Munich prize among monographs dealing with the surgery of the nervous system. The anatomy, the physiology, and the pathology of the sympathetic system are not sufficiently known to build upon such scanty knowledge practical clinical conclusions and applications.

All this is frankly stated by Scalone, who, however, gives an admirable résumé of the present-day knowledge of the anatomy, physiology and pathology of the sympathetic system. The value of this résumé is enhanced by splendid original illustrations and valuable personal considerations and investigations.

The clinical part of the work is dealt with in fifteen chapters, the most important of which are the ones referring to Scalone's original work. Thus the chapters dealing with the sympathetic innervation of the vocal cords and the ones where he illustrates the advantages of his technic of neural sympathectomy are of great interest.

Scalone contends that neural sympathectomy, in many cases, is more effectual and has a broader field than Leriche's vasal sympathectomy. He shows that many peripheral nerves carry a large number of sympathetic fibres, and that certain territories are consequently greatly benefited by neural sympathectomy, if the proper nerve is selected. He insists on thorough anatomical, physiological and pathological knowledge on the part of the surgeon who wishes to attempt to do surgery of the sympathetic system.

The histories of forty-four personal cases complete the monograph.

The uncertainty existing about the sympathetic system is plainly reflected

## BOOK REVIEWS

through every page of the monograph. This makes it really valuable. The early enthusiasm of numberless biologists and surgeons about Leriche's operation and all other procedures aiming at destroying the fibres of the sympathetic nerve, entering nerves, blood-vessels, glands, *etc.*, is absent. A sober endeavor to restudy thoroughly the whole subject, beginning from its anatomical and physiological basis, without being swayed by enthusiasm or discouraged by poor results, makes Scalone's monograph most praiseworthy.

Scalone's monograph should be consulted by anyone intending to do surgery of the sympathetic system, because it relates the personal, unbiased experience of an intelligent, competent, hard-working surgeon and biologist who has devoted twenty years to the study of the subject.

ANGELO L. SORESI.

UROLOGICAL ROENTGENOLOGY. (Second edition revised.) BY HUGH A. YOUNG, M.D., AND CHARLES A. WATERS, M.D. 4 vo.; cloth; pp. 560. Paul B. Hoeber, New York, 1931.

The review of the first edition of this work appeared in the *ANNALS OF SURGERY*, vol. lxxxix, No. 3, March, 1929. The remarks made then may be reiterated. A second printing of the volume necessitated at this time has given the authors an opportunity of incorporating the advances in urology made during the past two years and of revising and elaborating the previously written chapters. Thus, many new and interesting cases have been incorporated, gathered both from the literature and from recent cases in the Brady clinic.

Since the publication of the first edition, the subject of intravenous urography has been developed and a new chapter devoted to the details of its administration has been added. The discussion of the evaluation of these new methods is of definite value. A second chapter takes up the consideration of the more recent technic of arteriography and depicts graphically the delineation of the aorta and its abdominal branches in urological roentgenology. A few pages have also been added showing the clinic methods of keeping records. The new Young-Elvers phthaleinometer is also illustrated and its use described.

In all, sixty-four pages and seventy-four illustrations have been added to the original work. The general composition of the volume is most excellent and will prove of great value not only to the specialist, but to the general practitioner and surgeon as well.

JAMES T. PILCHER.

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